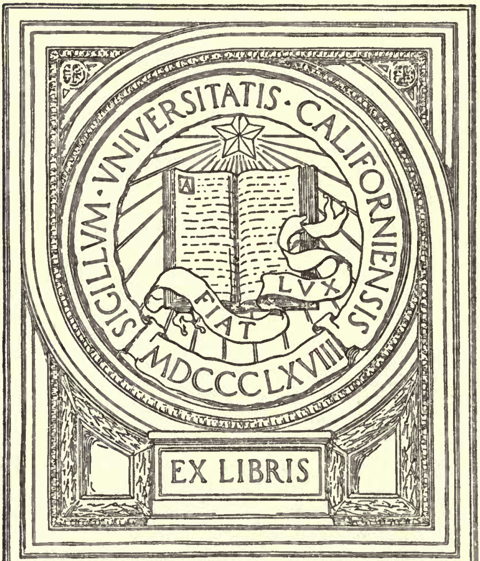
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PLANT DISEASE

PLANT DISEASE

AND ITS RELATION TO ANIMAL LIFE

BY

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LONDON
SWAN SONNENSCHEIN & CO LTD
PATERNOSTER SQUARE
1903

PREFACE

In an address to the North British Branch of the Pharmaceutical Society, by J. Arthur Thompson, Professor of Natural History in the University of Aberdeen, delivered in 1901, the following passage occurs :—

"Even in my few illustrations I have probably made mistakes by touching subjects which are beyond my field of work, but to pounce upon these is to ignore the whole aim of my address, which is to suggest that the various departments of science—yours and mine and that of others—are all correlated. It is not solely by the aloofness of specialism, but by mutual interest, and active co-operation as well, that we make progress in understanding the one problem which, in some form or other, is before us all—The Order of Nature."

In the following pages, I may perhaps to

some appear to be too discursive, but I base my defence on the complexity of the subject with which I deal, and on the plea that it does in effect touch upon such varying departments of science as chemistry, pathology, physiology, and their practical branches. To understand the theory that I here advance, a recognition of the claim put forward by Professor Thompson for a sympathetic and unbiassed inquiry into the Order of Nature is the first necessity.

E. F. W.

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CHAPTER I

INTRODUCTION

It is commonly recognized that what is known as chlorophyll is an essential constituent of healthy plant life, and its absence, or presence in insufficient quantity, is the cause of chlorosis, which is one of the most formidable diseases to which plants are liable. This chlorotic condition is due to an absence of iron, as without iron chlorophyll cannot be formed (see *Encyclopaedia Britannica*, vol. xix., p. 52), and is often successfully treated by washing with a weak solution of sulphate of iron. Now what chlorophyll is to the plant, haemoglobin is to the animal, the one being a red modification of the other, as I shall show in a later chapter, and Macallum holds (see *Colour in Nature*, by Marion J. Newbigin, D.Sc.) that chlorosis in plants and animals is due to the same cause, a deficiency of iron. It follows from this that herbivorous animals eating chlorotic food,

must necessarily fail to assimilate the requisite quantity of iron, and will consequently have a tendency to become anaemic, a condition as formidable to health in the animal as is chlorosis in the plant, as is recognized by various authorities. A brief survey of the construction and functions of the haemoglobin will make this clear.

In *Animal Physiology*, p. 119, W. S. Furneaux says—

"The colour of the blood is due to the presence of a nitrogenous substance, called haemoglobin, in the red corpuscles. This substance contains a considerable proportion of iron oxide."

Again, in the *Encyclopaedia Britannica*, article "Iron, Therapeutic Uses of," vol. xiii. p. 359, we read—

"If the haemoglobin of the blood fall below a certain standard, the supply of oxygen necessary to healthy tissue changes in brain, nerve, muscle, etc., becomes too limited, and the changes will be imperfectly performed, hence defective vitality general or local."

Again—

" In the lungs, the corpuscles through their haemoglobin take up oxygen which they carry to all parts of the body. But in the presence of the vital processes of disintegration and repair constantly going on in the tissues, the corpuscles yield up the oxygen they have brought and supply an element necessary for these processes."

Therefore in an anaemic blood there cannot be a sufficiency of oxygen taken up.

" Having got rid of the oxygen the haemoglobin then unites with the carbonic acid produced by tissue disintegration, and the corpuscles thus re-laden carry their burden back to the lungs, and discharge there the carbonic acid " (*Encyclopaedia Britannica*, vol. xiii. p. 359).

Thus in anaemic blood, which can be undoubtedly produced by anaemic food, there would not be a proper discharge of carbonic débris.

This in my opinion constitutes the certain

group of symptoms, "which," says Rindfleisch, "recur with the uniformity of a type in the most various diseases, depending as they do upon one constant factor" (*Encyclopaedia Britannica*, under "Pathology," vol. xviii. p. 361).

Now if we return for a moment to chlorophyll, we find another factor of great importance, namely, that "In green plants it is only those cells which contain chlorophyll that can absorb carbon dioxide, and this only under the influence of light, a sufficiently high temperature and a supply of iron" (*Encyclopaedia Britannica*, vol. xix. pp. 48 and 52).

Hence green plants deficient in chlorophyll will be deficient in carbon dioxide; in other words, chlorotic plants are wanting in carbon as well as in iron, because all carbon compounds, whether in plants or animals, are derived directly or indirectly from the organs containing chlorophyll.

Another important feature which, though not fully recognized to-day, will, I think, be in the near future, and on which I give some

evidence further on, is that iron is the means of fixing the ammonia of the air in the soil to form nitrates. In any case, I am sure there is a fixed law by which the ammonia of the air is fixed in the soil to form nitrates, just as chlorophyll is the medium by which carbon dioxide is fixed in the plant.

This is important, as the loss of carbon and nitrogen can only be replaced by the use of organic food substances, and cannot be supplied from the air as oxygen can with the assistance of a normal haemoglobin.

It is of the utmost importance that the loss of carbon and nitrogen should be made good, where they are wanting in chlorotic food, seeing that carbon enters into the composition of all the organic substances such as the carbohydrates, hydrocarbons, proteids, etc. (*Encyclopaedia Britannica*, vol. xix. p. 48).

We see, then, that chlorotic food does not imply simply a deficiency in iron, but also a deficiency in carbon, which means that chlorotic food is wanting in sugars, fats, proteids, etc., and as the animal can only take in carbon by means of food substances, it also means that

animals eating chlorotic food must be deficient in sugar, fats and proteids.

Max Verworn, *General Physiology*, p. 158, says—

"The plant must construct the highly complex proteid molecule out of the simplest inorganic compounds, carbonic acid, water, salts and oxygen, while the animal obtains already formed the proteid food without which it cannot live."

But the proteids are only taken into the animal economy by means of the foods eaten. It follows therefore that if such foods be either chlorotic vegetable foods, or animal foods derived from animals fed upon chlorotic vegetable food, the individual so fed must be deficient in these necessary proteids.

Chlorophyll, which is before every one in the form of the green colouring matter of all forms of vegetation, from the leaf of the oak to the parsley leaf, is not of one constant standard. "Iron is absolutely essential to the existence of this compound, as chlorophyll cannot be formed

without the aid of iron" (*Encyclopaedia Britannica*, vol. xix. p. 52).

Yet there are many soils quite wanting in iron, and in the history of agriculture you never read of manuring with iron, excepting possibly in the case of some experimental plots, although some iron has been used of late years in the form of basic slag, which contains about 18% of iron, with beneficial results, as proved by experiments carried out by Dr. Somerville, especially in the case of stock grazing on pastures so manured.

Unfortunately, much vegetation is deficient in iron, and consequently chlorotic, and it would seem simpler instead of washing with sulphate of iron, as is now occasionally done, to have recourse to manuring the ground with iron, when the plant would in due course take up all it required for healthy growth.

The importance of this question of chlorophyll is so great that it may be as well to state once more the facts of the case.

Chlorophyll is never formed in the absence of iron. Only those cells in the plant that contain chlorophyll are capable of absorbing

carbon dioxide, and unless this is absorbed, the necessary proteids are not formed.

Animals, therefore, fed upon chlorotic food cannot absorb the chemical constituents necessary for health.

In a later chapter I propose to go more fully into the formation of the starch, sugars, fats, proteids, and protoplasm formed from the carbon dioxide taken up through the agency of the chlorophyll and to show that it is impossible for a chlorotic food to be as rich in these proteids, etc., as vegetable food which contains a sufficient percentage of iron, and consequently of chlorophyll.

Another point to be considered in relation to the haemoglobin is the important part it plays in the absorption of oxygen into the system. In the *Encyclopaedia Britannica*, vol. xiii. p. 359, we read—

" Each corpuscle consists of a stroma, permeated by a red fluid, haemoglobin, which has the remarkable property of readily combining with either oxgyen or carbonic acid, but so loosely that under slightly altered

conditions these gases are readily separated from it."

The haemoglobin, having such an affinity for oxygen, and oxygen playing such an important part in animal life, it is evidently of vital importance that the animal should have the maximum percentage of haemoglobin in the blood, yet there is ample evidence to show that there is great variation in the percentage of this proteid substance in the blood brought about by the varying amount of chlorophyll matter present in the food.

In the Introduction to his *Human Physiology*, pp. 37–38, Augustus D. Waller, M.D., F.R.S., states that in Disease the proportion of haemoglobin in the blood often falls from 12% to 1 or 2%.

It is also well known that the red corpuscles should be so numerous in the blood as to make it a thickish liquid, but the proportion varies considerably, as proved by analysis, as it is entirely dependent on the kind and amount of food eaten.

Having recognized the fact that there is a considerable variation in the percentage of

haemoglobin in the blood, we must also admit that there must be a corresponding variation in the quantity of oxygen taken into the system, and carbonic débris discharged, these being the special functions of the haemoglobin.

It is obvious, therefore, that an animal having a normal or rich haemoglobin will absorb much more oxygen into the system and discharge much more carbonic débris than will an anaemic animal.

And the extent to which the non-performance of these vital functions may extend, is measured by the fact above noticed, that it is possible for the proportion of haemoglobin in the blood to fall to one-twelfth of the normal.

Another important point in connexion with a defective haemoglobin is that—

"In breathing, nearly equal volumes of carbonic acid are lost and oxygen gained. Small quantities of other gases are given off from the lungs, including organic matter, which is exceedingly capable of putrefying, and which is no doubt highly injurious and the cause of much ill-health and of many diseases

where the products of breathing have been allowed to accumulate "

It is clear from the above that anaemia is the cause of, or at least a predisposing factor in, many diseases, and it is no doubt the constant factor in various diseases to which Rindfleisch refers in the passage quoted above.

It being once admitted that the percentage of oxygen absorbed into the system varies in about the same ratio as the percentage of haemoglobin in the blood, it becomes of interest to see how oxygen effects pathogenic bacteria.

Encyclopaedia Britannica, vol. xxi. p. 400, under "Schizomycetes"—

"The investigations of Cohen, Pasteur, Kock and others leave no doubt that many bacteria are sensibly affected by the media in which they are cultivated; not only are the forms modified, but also the physiological activity varies in degree and even in kind. The lung tissues of a healthy animal exert actions which are antagonistic to those of the parasite invader, and it is now generally admitted that the mere admission of bacteria

into an animal does not necessarily cause disease. Were it otherwise it is difficult to see how the higher organisms could escape at all. Something must therefore be placed to the action of the tissues of the host which, when healthy, can 'resist' the attempts of bacteria to settle, grow, and multiply with fatal effect."

"Pasteur has shown that anthrax bacillus cultivated in chicken broth, with plenty of oxygen, and at a temperature of 42–43C. lost its virulence after a few generations, and ceased to kill even a mouse. This has been confirmed by others" (see *Encyclopaedia Britannica*, vol. xxi. p. 400).

In tuberculosis again, it is universally recognized that oxygen is very beneficial, but the fact that thousands of cattle living in the open air suffer from it shows that it is not sufficient that the oxygen should enter the lungs, but that it is necessary that it should be absorbed into the system, which can only be accomplished by the action of a normal haemoglobin.

It is clear from the above that in certain diseases at any rate, and as I think in most, the animal having a normal haemoglobin is more

likely to be immune than one whose blood is defective. In other words, if my contention is correct, the susceptibility to certain bacterial diseases is directly traceable to the use of chlorotic food.

I shall develop this point at greater length, and with reference to other bacterial diseases, in later chapters, but it is sufficient for my purpose here to have shown a direct connexion between the bacillus and the chlorotic vegetable.

The variation in the supply of oxygen is an important factor in health *per se*, but it acquires additional importance from the fact that the discharge of carbonic refuse varies with it *pari passu*.

The variation in the discharge of carbonic débris derives its importance from the well-known fact that carbonic débris is a food for all pathogenic bacteria.

Hence, if we assume that in normal animal life, that is in every case where there is a normal haemoglobin, all this débris is discharged, it is an easy deduction that the undischarged débris will increase as the haemoglobin degenerates from the normal until the maximum

quantity of débris is retained in the system of an animal suffering from acute anaemia.

It follows that the food of these bacteria increases as the blood degenerates, and it is clear that they will increase more rapidly in those animals where the conditions are favourable to their growth, than in those where there is but a scanty supply of the food on which they thrive. To this may be attributed the variation in the virulence with which a given disease attacks different animals, some being by their physical condition a more fertile soil than others for the propagation of the pathogenic bacteria.

We may take as an illustration tuberculosis, where some cases linger on for seven or eight years and others die in as many weeks.

The greater the quantity of oxygen and the less the quantity of débris in any individual, the greater the immunity, while the converse condition provides us with the more acute forms of the disease.

But variation in these two factors does not cover the entire ground in relation to immunity or susceptibility in disease, for it is recognized that proteids are fatal to pathogenic bacteria.

In *Epidemics, Plagues and Fevers: their Cause and Prevention*, page 395, the Hon. Rollo Russell says: "Dr. Buchner ascribes immunity to proteid substances. Wild rats fed on plain bread for about six weeks, succumbed to anthrax with which they were inoculated, others fed on flesh did not take it, and their spleens were found to contain an abundance of the proteids."

Proteids, as stated above, are carbon compounds which must be taken in by the animal through the medium of food (*General Physiology*, by Max Verworn, p. 158).

I have shown that the carbon of the plant is governed by the chlorophyll, that the chlorophyll depends upon the iron, and that chlorotic plants must contain less carbon compounds than plants containing the maximum of iron and consequently of chlorophyll, from which it follows that a chlorotic plant will contain less proteids than a plant containing the maximum quantity of iron.

I have also shown that a normal food containing a normal chlorophyll is a food which will enable the animal to take up the maximum

quantity of oxygen and to give off the maximum quantity of carbonic débris, or food for pathogenic bacteria, at the same time storing up in the system the maximum percentage of proteids. Such an animal must be more immune than one with a deficient haemoglobin, where oxygen and iron are deficient and carbonic débris in excess.

In other words, the condition of immunity will vary directly with the assimilation into the system of normal food, and the degree of immunity will vary inversely with the amount of chlorotic food consumed.

In a later chapter I shall go more fully into the variations in the quality of given food products, as shown by chemical analysis, and hope to make it clear that to these variations are due in many cases the liability to contract disease and the lack of power to resist its effects which cause so many premature deaths.

I venture to think, however, that I have said enough to indicate the intimate relations existing between the animal and vegetable kingdoms, and to show that variations in the vegetable world must produce variations in the animal world, for which it provides food, and

that these variations or deficiencies are in the main the predisposing cause in many diseases.

In the following pages I shall try to show in a more or less detailed way how the quality of the food is governed by the mineral constituents present in or absent from the soil, how the variations in plant food affect the immunity or otherwise of the animal living on it, and how these variations, either directly or through the animal, affect man.

CHAPTER II

CHLOROPHYLL AND HAEMOGLOBIN

NATURALLY normal blood must contain the constituents of the whole body, as it is by this means that the wear and tear of the body is made good. For instance, the blood must convey to the nails, hair, teeth, etc., the constituents that go to build them up, and if it is wanting in these constituents, we see the teeth decaying, the hair falling out for want of nourishment, the nails becoming thin and weak like those of consumptives. Beyond the constituents that go to build up the parts there is the constituent which may be said to be the very essence of animal life, namely, haemoglobin. The functions of this constituent of the blood are so all-pervading that one can scarcely go too fully into the subject.

In the first place, it is admitted that arterial blood, that is, the blood as it leaves the lungs,

should be of a bright red colour when drawn from the animal ; this blood clots quickly, being of a uniform bright red right through the clot.

Now, if the blood were always of one constant and normal colour, we should not hear of many diseases ; but, unfortunately for the animal world, there is very great variation in the colour of the blood, an indication of variation in its chemical composition.

In the large number of animals that I have examined in South Africa the blood has more often than not been of a much darker or lighter colour than normal blood, when taken in a similar way in each case, namely, from the throat ; yet these animals were not showing any signs of disease, and to the ordinary eye were in normal health.

In many cases they had a very dark blood only partially coaguable, proving there is considerable variation in the quality of the blood of ordinary animals, which is easily explained and to be expected when one recognizes the great variation there is in the quality of the food eaten.

I have also noticed that whatever the disease from which an animal was suffering,

the blood was *always* abnormal, either being much darker or lighter than normal blood, and in every case more or less non-coaguable. In some cases of disease the blood has been so thin as to run into the soil like water, which a normal bright red blood could not do, as it would coagulate on the surface. Such normal blood contains a given percentage of nitrogen, iron, phosphoric acid and potash, while the blood of animals suffering from the class of diseases known as fevers is always more or less deficient in these constituents ; and it will be found that the more virulent the disease, the greater the deficiency.

It can be taken as an axiom that in all fevers the active agent is a bacterium, which is another name for one of the class of plants known as fungi. It is thought by many that it is the fungus that causes the chemical deficiency, while others say there must be a deficiency before the fungus can start its growth. I shall try to show that the first position is untenable. Some say that while the bacteria could not consume the iron, they might act on the blood chemically, so that the iron would escape from the system.

This suggestion seems to be an impossibility, brought forward to support a bad case, because it has been proved over and over again that iron is fatal to all fungi, consequently it is unreasonable to suggest that bacteria would attack a perfectly healthy animal, and destroy the blood containing a constituent which was a poison to them.

Secondly, if bacteria could attack all alike, the natural conclusion would be that it would not be long before these fungi would have destroyed all higher forms of life off the face of the earth.

That such is not the case, however, is proved by the fact that the majority of the doctors and nurses in consumptive hospitals always remain immune to this disease.

Further, it has been proved that where animals can obtain iron, they are much more immune to bacterial disease than in places where iron is wanting, from which we can only conclude that the presence of iron in the blood enables animal life to withstand the attacks of these bacteria, and as a corollary that the bacteria do not produce the deficiency, a conclusion which is further confirmed by the fact

that bacteria can only live on foods that correspond more or less with their own chemical composition.

Another factor is that proteids are fatal to bacteria, and the fact that a normal haemoglobin, which is of the nature of a proteid, is a poison to these, explains why these fungi are never found in a normal blood, for the all-powerful reason that they could not live in it.

This reduces the whole question again to the fact that a normal haemoglobin, through its various functions, which I have explained in the previous chapter, renders the animal immune to an innumerable number of bacterial or fungoid diseases, and explains the constant factor spoken of by Reindfleisch.

In other words, the blood is the life, and variation in its chemical composition simply means variation in the health of the animal. We know it is a common thing for animal life to die of acute anaemia. I shall show later how in anaemia there must be a proportionate deficiency of carbohydrates and proteids, and that they must vary as the haemoglobin.

In the proceedings of the *Royal Society*, vol. i.–xiii., 1898, page 389, is a paper on Chlorophyll, by C. A. Schunck, communicated by Dr. E. Schunck, F.R.S.

He says: "The very near relationship that has been shown to exist by Schunck and Marchlewski between phylloporphyrin (a chlorophyll derivative) and haematoporphyrin (a haemoglobin derivative), and the remarkable resemblance of their absorption spectra—one may almost say they are identical. But further on I will show that this particular resemblance in these two derivatives is only partly correct, the band in the phylloporphyrin I examined being double, though occupying the same position as the single one of the haematoporphyrin."

This statement is both interesting and important, but I desire to lay more stress upon the resemblance observed by C. A. Schunck than upon the difference in the spectra, because I believe such difference would be fully accounted for if the phylloporphyrin were obtained, say, from a rice plant containing

no iron, while the haematoporphyrin was from a haemoglobin produced by a food rich in iron, nitrogen, phosphorus and potash. It is, in fact, my contention that the phylloporphyrin and the haematoporphyrin would vary as the soil and food producing them, and that the phylloporphyrin of a chlorophyll containing the maximum of iron and nitrogen would be identical with the haematoporphyrin of a haemoglobin produced by a plant life containing a normal chlorophyll. It is at least a reasonable presumption that a normal chlorophyll, that is, one containing the maximum of iron, nitrogen and phosphates, or any of its derivatives, would produce different results in the spectrum to those obtained from a chlorotic chlorophyll or any derivatives of it. In the same way, a normal haemoglobin or any derivatives of it would be likely to produce different results in the spectrum to the results obtained from an anaemic haemoglobin or any derivatives of it.

From these natural assumptions it would follow that the phylloporphyrin obtained from a normal chlorophyll would produce different results in the spectrum to the results obtained

from an anaemic haemoglobin; and if this is admitted, as I think it must be, then it follows that the phylloporphyrin and the haematoporphyrin will, in their relation to each other, pass through the whole gamut of variations that can be obtained in either the chlorophyll or haemoglobin, or both.

Further, I believe if the chlorophyll of a given pasturage, or any of its derivatives, were tested or compared with the haemoglobin, or any of its derivatives, of animals grazing on the said herbage for a sufficient length of time, that the chlorophyll and the haemoglobin, or any of their derivatives, would be found to be similar or identical when tested by the spectrum.

Indeed, it seems likely that the time is approaching when spectrum analysis will be employed as the best method of ascertaining the relative value of foods.

In *Encyclopaedia Britannica*, vol. xix. p. 48, we read—

1. "In green plants it is only those cells which contain chlorophyll that can absorb

carbon dioxide, and this only under the influence of light."

2. "The feeding of plants upon carbonic acid is invariably accompanied by the presence of a peculiar green colouring matter. Chlorophyll, the protoplasm of the plant, is enabled to seize the carbon of the mineral world. There are plants which have no chlorophyll, and are thus unable to feed upon carbonic acid."

Further, in *Text-Book of Botany Morphological and Physiological*, by Julius Sachs, Professor of Botany in the University of Wurzburg, edited by Sydney H. Vines. D.Sc., F.L.S., we read—

3. "It is only the cells which contain chlorophyll, and only those under the influence of sunlight that have the power of decomposing the carbonic dioxide taken up by them. The compound of carbon originally present in the earth is the dioxide, and the only abundantly active cause of its decomposition and of the combination of carbon with the elements of water is the cell containing chlorophyll. Hence all compounds of carbon of this kind, whether found in plants or in

animals or in the products of their decomposition, are divided directly or indirectly from the organs of the plants which contain chlorophyll."

Encyclopaedia Britannica, vol. xix. p. 52 says—

"The general conditions upon which chlorophyll is formed are light, heat and supply of iron."

Plants which have grown in absence of a supply of iron are said to be chlorotic.

In *Encyclopaedia Britannica*, vol. xix. p. 53, Hansen says: "The only normal ash constituent in chlorophyll is iron."

Iron is known to be essential only to those plants which contain chlorophyll. If pale leaves be painted over with a dilute solution of iron they will soon become green. Iron, therefore, plays an important part in connexion with the green colouring matter chlorophyll.

From the above quotations it is clear that

the carbon of the plant is due to the presence of chlorophyll in said plant, while I have shown in the previous chapter that the presence of chlorophyll is dependent upon the presence of iron in the soil, from which it is evident that the carbon of the plant, with its products, is governed by the iron.

We know that carbon and its products in animal life are supplied in the food, therefore it is imperative for plant life to have sufficient iron.

I have also shown that chlorosis of plants is a most formidable disease, and it is clear that there must be a large number of animals living entirely or partly on this chlorotic vegetable food, from which it follows that a large portion of animal life must be more or less anaemic through eating this chlorotic food.

It is well known that innumerable diseases in animal life are accompanied by anaemia, and it seems evident that the eating of such chlorotic food will produce the anaemic state of the blood which is always found in connexion with the development of certain diseases, and which, I contend, precedes that development. Proof to the contrary, at

least, cannot be adduced, as it would be necessary to show that the blood was normal prior to the appearance of the disease in a particular individual, which is practically an impossibility. With regard to the extent of possible variation in the haemoglobin, and the consequent capacity of the blood to perform its normal functions, I may quote Dr. Waller, F.R.S., who says, in his *Introduction to Human Physiology: Composition of Blood in Disease*, p. 37, 38—

"The popular term 'poverty of blood' is accurately descriptive. The blood of an anaemic person is not deficient in amount, but it is weak blood, with an excess of water and a deficiency of solids, and a low specific gravity, 1,030 to 1,040. The number of red corpuscles is deficient, and the amount of haemoglobin in these is even deficient. Contrasting the blood of a healthy person with that of a patient in extreme anaemia, there have been found, for instance—

Proportion of water	88%	instead of	80%
,, ,, solids	12%	,,	20%

Specific gravity	1035% instead of 1055%
Number of red corpuscles per cubic MM.	1 to 2 millions instead of 4 to 5 millions
Proportion of Haemoglobin	1 to 2% instead of 12%

From which it is evident that the deficiency is essentially a deficiency of haemoglobin."

It being recognized that the haemoglobin is the conveyer of oxygen in and through the system, and the means of discharging carbonic acid from the system, we have here distinct evidence that some human beings can take twelve times as much oxygen into the system and discharge twelve times as much carbonic débris as others.

In other words, one individual may provide twelve times as much food for pathogenic bacteria as others. Nor is this any proof that this is the limit of the possible variation between extreme anaemia and a normal condition of the blood, for in the vegetable kingdom a greater divergence in the chemical constitution of food stuffs has

been traced, as in the case of two samples of oats, where one showed sixteen times the quality of the other.

Carbon

Before leaving the subject of chlorophyll, there is one other point to be considered, namely, its functions in the formation of the carbon compounds to which are due the proteids, fats, sugars and starch required in the plant, and consequently in the animal economy.

In *General Physiology*, by Max Verworn, pp. 158, 159—

"As to the fate of the retained carbon, microscopic observation gives us information. It shows, namely, that in proportion to the destruction of the carbonic acid, starch is formed in the chlorophyll-grains themselves, and is laid down in the form of small highly refractive granules. Moreover, by a series of experiments, Sachs has shown as soon as the breaking up of the carbonic acid ceases in darkness, the formation of starch also ceases. Since starch only contains, in addition to

carbon, only hydrogen and oxygen in the same relative proportion as in water, it can only be derived by synthesis from the carbon that is set free, and the water that is received through the roots."

"If," says Sachs (82), "starch is the first and sole visible product of assimilation, it follows directly that all other organic compounds of the plant must originate by chemical metamorphosis from it. If, therefore, later the plant manufactures other carbohydrates, fats, and finally proteids, all of which contain carbon, it can only employ starch as the starting point.

"The plant must construct the highly complex proteid molecule out of the simplest inorganic compounds, carbonic acid, water, salts and oxygen, while the animal obtains, already formed, the proteid food, without which it cannot live."

From the foregoing evidence it is clear the carbon compounds of plants are obtained from the carbon of the starch, and, as I have previously pointed out, the carbon of the plant, and therefore of the starch, is governed

by the chlorophyll, and the chlorophyll is governed by the iron and nitrogen that plants find available.

Therefore other carbohydrates, fats, and finally proteids must be controlled by the chlorophyll food of the plant, and as animal life obtains its proteid food already formed, then it follows that the proteid food of animal life must vary as the proteids in the food eaten. That this variation is considerable I shall show in the following chapter.

Animal life, then, deficient in proteids, through a corresponding deficiency in the food eaten, becomes more or less devitalized, and consequently more or less liable to various bacterial diseases; further, when the animal contains these proteids in anything approaching normal quantities, the said animal is immune to innumerable bacterial diseases, as it is admitted that pathogenic bacteria cannot live in the presence of proteids. (See chapter on Immunity.)

To show the value of carbon compounds in food—

I remember some twenty years ago a flock of ewes and lambs were driven past a country

blacksmith's shop, and one lamb was too weak to continue with the flock, and was brought up by the children of the blacksmith by whose shop it was passing at the time.

This lamb grew up by grazing on the grass growing round this shop, and was shorn three times in three years, giving the splendid clip of wool of twenty-eight pounds in three years. I have often wondered why this stray lamb should have developed into a sheep giving such good clips of wool. This now appears easy of explanation.

In the first place, it is quite certain there would be plenty of iron in the soil for some distance round a country blacksmith's shop, owing to rusty iron being carried about, to say nothing of the scales of iron and iron filings produced by the working of iron, which would be swept out of the shop.

And, irrespective of the nitrogen that would be obtained, either directly or indirectly, through the chemical action of the iron, there would be plenty of nitrogen from the hoof parings which were swept out in the same way as the iron scales and filings.

So it is quite certain the grass growing in

close proximity to the shop would contain all the iron and nitrogen it required, and would consequently be fairly rich in carbon compounds and proteids, from which it must be clear that this sheep would be rich in the same, and as wool is largely a carbon compound, we have at once an explanation of the excellent fleeces produced by this stray sheep.

It is, I think, unquestionable that the chemistry of the carbon compounds of animal life containing a normal haemoglobin must be different to that of the carbon compounds of an anaemic animal. Further, I think it will be found that the carbon compounds of an animal containing a normal haemoglobin are a poison to pathogenic bacteria, whether fungi or the lowest forms of animal life, such as are said to produce malaria; but when the animal becomes anaemic, then the carbon compounds become more or less changed, and in so changing become foods for pathogenic bacteria.

That there is nothing unreasonable in this view is shown by the fact that a carbon compound like sugar $C_{12}\ H_{22}\ O_{11}$ is harmless to animal life, while strychnine $C_{12}\ H_{22}\ N_2\ O_2$ is a

deadly poison. If such a slight change can make the difference between a food and a poison in animal life, it is reasonable to think that a slight change in the carbon compounds of the animal can make the difference between a food and a poison for fungi ; and there is no question that such a variation may well exist between animals in a normal and those in an abnormal or anaemic condition.

I have tried to make it clear that it is absolutely imperative for the health and development of the human race that chlorotic plant life must be removed from the surface of the civilized globe, for every one knows there are an innumerable number of carbon compounds in both plant and animal life ; and as it is clear that the carbon of plant life is governed by the iron, to say nothing of the other mineral constituents, so must the carbon compounds be governed in the same way, and as the whole series of carbon compounds of the herbivora are governed by the carbon compounds of the vegetable foods they eat, so must they vary as the state of the chlorophyll. And as man lives by the products of vegetable and animal life, so must the various chemical

compounds found in man vary as they vary in the vegetable and animal foods eaten.

In *Encyclopaedia Britannica*, vol. xix. p. 50, we find—

"The formation of organic nitrogenous substances may take place in any living cell, and, unlike the formation of non-nitrogenous organic substance, it goes on quite independently of the presence of chlorophyll and of the action of light. But there is evidence to show that in green plants it is especially in the cells which contain the chlorophyll, that the process goes on."

The importance of this statement lies in the fact that though nitrogenous substances can be produced in chlorotic plants, still the process is incomplete, and the quantity produced less than the normal. In other words, the amount produced will have a certain ratio to the chlorophyll, and hence to the iron.

Hence animals living on chlorotic vegetation will not only be deficient in iron and various carbon compounds, but also in nitrogenous compounds or proteids. The fact previously quoted, that proteids can only be

formed in the animal from this production, is a further confirmation of my theory that the haemoglobin of the animal (a nitrogenous compound) must vary in the animal as the chlorophyll varies in the plant.

CHAPTER III

VARIATION

In the Introduction I referred to the wide variation in the chemical composition of various vegetable products arising, as I contend, from variation in soil and methods of cultivation. Under the first head I append the analysis of two soils from the same farm in Canada, one virgin, the other cultivated.

In the report of "Experimental Farms of the Canadian Department of Agriculture for 1899" are the analyses of two soils taken from one farm, and considered representative soils of the district—

	No. 1. Virgin Soil.	No. 2. Cultivated Soil.
Moisture	3·91	1·78
Organic and volatile matter	8·04	5·49
Clay and sand	73·17	81·51
Oxide of iron and alumina	13·80	9·85
Lime	·89	·02
Potash	·51	·35
Phosphoric acid	·24	·12
Nitrogen	·158	·103

From this analysis the variation or deterioration in the chemical properties of the soil under cultivation is clearly shown. As further evidence on this point of soil variation I quote from *Spon's Encyclopaedia of the Industrial Arts*, Division V. p. 1864:

"The composition of cane soils may be illustrated by two analyses by Dr. Phipson, one (A) of a soil from an estate in Jamaica under cane for the first time, the other (B) from a Demerara plantation worked for more than fifteen years consecutively"—

	A.	B.
Moisture	12·25	18·72
Organic matter and combined water	15·36	6·03
Silica and insoluble silicates	48·45	68·89
Alumina	13·80	2·50
Oxide of iron	6·72	2·60
Lime	0·99	0·08
Magnesia	0·29	0·25
Potash	0·11	0·10
Soda	0·70	0·09
Phosphoric acid	0·10	0·03
Sulphuric acid	0·30	0·03
Chlorine*	0·51	trace
Oxide of manganese, carbonic acid, and loss in analysis	0·42	0·68
	100·00	100·00
Nitrogen in organic matter	0·31	0·05

* This quantity of chlorine is unusually high, which is accounted for by the proximity of a salt spring.

We thus get the same effect in the cane soils.

Of course, it is a recognized fact in agriculture that any crop will deteriorate the soil in which it is grown, unless what it takes out is put back in the form of manure.

It is clear in both these cases that the deficiency has not been made good, and consequently that the plant has no longer the same store of chemical constituents to draw upon as when the land was first planted. It is only reasonable to suppose that under such conditions it will be deficient in some degree in these constituents. An examination of a series of analyses of food and other products will clearly show that this is often the case, and it may not be too strong a statement to make, that faulty agriculture of this nature is the rule rather than the exception, the sufferer being first the farmer himself and secondly the consumer.

Taking first a crop of the utmost importance, namely, wheat.

In *Watts' Dictionary of Chemistry* you will find the phosphoric acid in wheat varies between 14·5 and 60·2, potash varies between 9·4 and 35·6, iron varies between 0·1 and 3·3

of the ash, and so through all the constituents of the plant, with a possibility, if the subject were thoroughly investigated, of even greater variations. This appears to be an irregularity owing to a greater or less deficiency, or to an unassimilable state of the plant food.

I shall now try to show that these variations are the chief governors in the yield of wheat, and other farm products. It is fully recognized that iron and nitrogen in combination with the phosphates are the means by which the plant is enabled to take up the carbon of the air, to form the common carbon compound, starch, and from this starch the various carbon compounds of the plant are formed. So we may say the carbohydrates and hydrocarbons of the plant are governed by the percentage of available iron, nitrogen, and phosphates in the soil. I have already shown that these minerals have a very wide variation in the cereal produced, therefore we may argue that there has been a corresponding range of assimilable mineral matter in the soils from which these cereals have been produced. We can now go to the natural deduction that the grain wanting in these mineral constituents will also be wanting

in carbohydrates, etc., and as these go to form the large bulk of wheat and other vegetable matter, it follows that a soil poor in available mineral matter will give a poor yield of wheat.

As outside testimony in support of what I have stated, Professor Tanner, in his report of various grains (which report can be seen hanging on a wall of the South Kensington Museum Science Department), shows "how two crops of oats grown upon similar land, under similar conditions of climate, gave different yields, one giving 80 bushels to the acre, and each bushel weighing 40lb., while the other crop only gave 10 bushels to the acre, and each bushel only weighed 22lb. He shows that the flesh, fat, and heat-producing properties of the one were sixteen times greater than the other, and concludes by saying that the difference of produce arose from good and bad farming respectively. He also shows that the ash of the one grain was more than sixteen times greater than the ash of the other.

This great increase in the quantity of the ash goes to prove my statement that the yield of grain is governed by the mineral constituents,

and as the larger yield of grain was also sixteen times better than the poorer one in its feeding qualities, it is reasonable to think, if the whole of the wheat of Great Britain was grown to produce the maximum yield, that owing to its greater flesh, fat, and heat-producing properties, any given quantity of it would go further in feeding the people than the average quality does to-day.

Again, take the variation of iron in various cereals.

This is given by Watts in his *Dictionary of Chemistry*, on page 826—

In wheat	Fe_2O_3	ranges	between	3·3	& a	trace
,, Oats	,,	,,	,,	5·1	and	0·1
,, Barley	,,	,,	,,	2·1	,,	0·1
,, Rye	,,	,,	,,	2·2	,,	—
,, Maize	,,	,,	,,	0·8	,,	0·5
,, Rice	,,	,,	,,	—		—

All the other mineral constituents of cereals and other foods have just as wide a range as the iron.

A similar variation is noticeable in the potato—

From *Watts' Dictionary of Chemistry* —Diseased potatoes unfit for food either for man or beast.		*Foods: Their Composition and Analysis*, by Wynter Blyth, on pages 218, 219, gives the composition of the ash of the potato according to 53 analyses by E. Wolff.		
	No. I.	Minimum. No. II.	Maximum. No. III.	Mean. No. IV.
Potash	37·86	43·95	73·61	60·37
Soda	3·12	—	16·93	2·62
Lime	2·80	0·51	6·23	2·57
Magnesia	0·60	1·32	13·58	4·69
Ferris oxide . . .	0·89	0·04	7·8	1·18
Phosphoric acid . .	9·96	8·39	27·14	17·33
Sulphuric acid . .	5·44	0·44	14·89	6·49
Silica	6·12	—	8·11	2·13
Chlorine	6·96	0·85	10·75	3·11
Carbonic anhydride .	17·02	Not given.		

Nor are drugs free from variation, as the following from *Medicinal Plants*, by Robert Bentley, F.L.S., M.R.C.S., and H. Trimen, M.B., F.L.S., vol. ii. p. 140, under Composition, indicates. Cinchona Bark, showing variation of same as recognized by analysis—

"The analyses of Howard show that the different varieties of Loxa or Crown bark vary very much in the proportion of alkaloids they contain. Thus the original or old Loxa bark yielded him an amount of alkaloids equalling

the total obtained from some specimens of the Calisaya bark. In the larger and thicker rusty crown he found from 2% to 3% of alkaloids, chiefly cinchonidia, but also more or less quinia. In the yellow and red crown varieties he also found cinchonidia associated with traces of quinia and cinchotannic acid. A very fine specimen of fixe crown yielded 1½% of cinchonidia and quinia with much cinchotannic acid; but on an average, specimens of this bark only yielded him from 0·50% to 1% of alkaloids. According to the British Pharmacopoeia 20 grains of pale cinchona bark should yield not less than 1 grain of alkaloids. Specimens of pale bark from India yielded Howard varying proportions of alkaloids thus from about 4·30% to 6·40%.

In *Dictionary of Applied Chemistry*, by Thorpe, vol. ii. p. 714. Under "Nux Vomica examined by this method"—

Bombay	seeds	gave	from	3·14 to 3·90%
Cochin	,,	,,	,,	3·04 to 3·60%
Madras	,,	,,	,,	2·74 to 3·15%

Of total alkaloids D and S.

"The experiments of Siebold, Dunstan and Short, and Conroy proved that the pharmaceutical preparations of Nux Vomica, the extract and tincture, vary materially in alkaloidal strength.

"This variation is overcome by Dunstan and Short as far as the medical tinctures are concerned."

Such instances could be multiplied indefinitely, but I have quoted sufficient statistics to show the wide range of deterioration of which the vegetable world is capable. Can it be doubted that the result of these variations must be in many cases to provide man and beast with a food incapable of supplying him with the bare chemical necessities of life, irrespective altogether of the economic side of the question from the farmer's point of view?

To pass from the plant to the animal, I have already in the previous chapter referred to the variation in the blood, as shown in what is considered as normal and the acute anaemic condition.

I now append analyses of two samples of

milk, one from a healthy, the other from a tuberculous cow.

In *Milk: its Nature and Composition*, by C. M. Aikman, on page 11, under "Percentage, Composition of Milk" gives the range of—			In *Foods: their Composition and Analysis*, by J. Winter Blyth (fourth edition), page 297. A sample of milk drawn from the udder actually infiltrated with tubercular deposit in 100 parts by weight.
	Maximum.	Minimum.	
Water	91·41	81·1	94·640
Fat	8·0	0·8	0·490
Nitrogenous substances commonly known as Caseine and Caseous matter .	5·73	2·0	3·597
Milk Sugar . .	6·0	3·0	0·470
Ash	0·9	0·6	0·764

This then is a phthisical milk in its most intense form, and one never likely to be found in commerce, but admixture of such a fluid with genuine milk is possible.

I shall give further instances of such variation which have come under my own observation, in the chapter on animal diseases. It is of interest, however, to note one remarkable case of variation, namely that of Glycogen.

In *Text Book of Physiology*, by Foster, vol. ii.

pp. 750, 751, the author points out that "Glycogen is a carbohydrate compound found in the liver, and that this glycogen is plentiful in the liver of a well-fed animal, and that by starving an animal the glycogen can be reduced to a mere trace, which can be again increased by feeding an animal on foods rich in carbohydrates."

I have previously pointed out that the carbohydrates of the plant are governed by the chlorophyll of the plant, and must consequently vary with the chlorophyll.

Owing to the close connexion between the chlorophyll and the haemoglobin, this variation must also be reproduced in the haemoglobin and the carbohydrates of the animal, glycogen being, as we have seen, dependent upon the quantity and quality of the food consumed, it follows that an animal grazing on good land will have a sufficiency of glycogen while one grazing on poor land will be deficient in that constituent, and hence more liable to disease of the liver. This should be so in theory, and according to my own experience is so in practice.

From this it follows that as the chlorophyll and the carbohydrates vary, so will the haemoglobin and the carbohydrates, including glycogen, vary in the animal, and as a well fed animal contains more glycogen than a starved one, if follows that two fields, one containing all the chlorophyll constituents, and the other very deficient in the same, must produce two very different kinds of herbage. Consequently the sheep or other animals grazing on the pasture produced by these two fields must be chemically different in so much that the animals grazing on the normal pasture will have the maximum of glycogen in their livers with the minimum of food, while those grazing on the chlorotic food will have the maximum of food with the minimum of glycogen, with its surrounding disadvantages, which will include biliousness and other liver diseases.

It is clear from the foregoing that if a variation in the food can produce a variation in the quantity of the glycogen, that a variation in the quantity or quality of the food for any length of time must produce a deficiency of other carbohydrates in the animal, and if the carbohydrates can be effected by the food then

the whole chemistry of the animal can be effected, hence disease.

In the same Text Book, vol. ii. p. 781, we find—" It will be remembered (§ 244) that bile contains a distinct quantity of iron, which probably has its origin in the iron thus set free from the haemoglobin and retained in the hepatic cell."

From this it is a fair deduction that the quantity of iron set free from the haemoglobin will vary according to the percentage of iron in the haemoglobin, and it is a fact that an anaemic haemoglobin has a less quantity of iron to set free than a normal haemoglobin.

It follows, therefore, that blood rendered anaemic by eating chlorotic food is likely to produce a diseased liver—a view which I think is more in accordance with common sense than that of those who hold that it is the diseased liver which produces anaemia, which is considered to be the case by some.

In the same book, volume and page we read—" The hepatic substance is found to contain a small quantity of iron sufficient to give the cells a diffused dark colour when treated with

ammonium sulphide ; the exact amount appears to vary largely, but the causes of the variation have not been determined."

Can there be any question that the variation in the quantity of iron found in the hepatic substance varies according to the quantity of iron in the haemoglobin which again varies as the iron in the food eaten ?

But of all forms of variation perhaps the various degenerations of protoplasm are the most to the point in this connexion.

"The healthy appearance of the most elementary kind of protoplasm is a soft translucent grey ; under the microscope this greyish protoplasm is uniformly and finely granular. From this standard of health there are various deviations, representing various kinds and degrees of degeneration. The chief degenerations are the mucous, the albuminous, the fatty, the calcareous, the caseous, and the amyloid. Under the head of caseous are collections of pus, as in chronic abscess of the liver, or pus in the pleural cavity, which are liable to the same process of drying up and molecular

disintegration. Under all cases the caseous change follows upon a certain amount of hyperplasis of the tissues, for the maintenance of which there has been no adequate provision of new blood vessels."

Here we have it directly admitted that there is variation in the protoplasm, which is itself a proteid; therefore one cause of variation in this very important constituent, which is considered to be the germ of life, is variation in the quality of the food, so that the very germ of life is influenced or controlled by the food eaten; for it is not too much to assume that a normal food must produce, or tend to produce, a normal protoplasm, and consequently that a chlorotic food must tend to produce protoplasm of various degrees of degeneration, and no doubt individual deficiencies would tend to special degeneration.

For instance, "Lecithin, a nitrogenous phosphorized fat, and like fats are thought to be formed from the protoplasm" (*Encyclopaedia Britannica*, vol. xix. p. 53).

Then as there is a deficiency of lecithin in consumptives, it follows that there is a deficiency of protoplasm.

This is confirmed by the well-known fact that there is a calcareous deposit in the lungs of consumptives, a degeneration mentioned under protoplasm. According to chemistry, I fail to see how this calcareous deposit could take place if there were anything like a normal percentage of lecithin in the lungs, which gives under normal conditions an acid reaction owing to an excess of phosphoric acid present in the lecithin found in the lungs, for such an acid would dissolve any such calcareous deposit. This deficiency of phosphoric acid is further confirmed by the fact that insanity and consumption are closely allied, and the bones of the insane are known to be very brittle, due to a deficiency of phosphoric acid in them.

The following quotations may be taken as evidence that phosphoric acid hardens bone.

The *Text Book of Pharmacology*, by J. Lauder Brunton, on pages 627 and 710, says—"Phosphate of sodium is given to children who have rickets, in order to supply phos. acid to the bones." The same work says—"When phosphorus is given to growing animals the bone is denser than usual."

In *Medical Tracts*, on pages 16, 17 and 19, Dr. Kirkby says—"We conclude that therefore dephosphorized blood is incapable of supporting the nutrition of the cerebrospinal centres, and that functional disorders frequently result." He also says: "No doubt it has become deficient in the system from an insufficient supply of the element in the animal and vegetable substances taken as food."

In *Medical Dictionary*, by Gould, the author says: "Phosphorus in form of phosphoric acid, combined with calcium, forms a high percentage of bone, being an essential element in bone, brain, and nerve tissues."

If there were sufficient acid in the bone to make it hard, it would be likely that there would be sufficient acid in the lungs to give an acid reaction. Again, fatty degeneration is recognized as due to a deficiency of oxygen. This deficiency, I think I have made clear, is due to a defective haemoglobin, and other degenerations may be due to a simple or complex degeneration as in the case of cancer, where I am satisfied there is a deficiency of haemoglobin and phosphoric acid, while insanity and phthisis are deficient in the same.

There may be some who think there is no other deficiency than simply the iron, nitrogen, phosphoric acid, or potash. This is a very short-sighted way of looking at it, as these constituents should be taken in the food, which can only be done if they are present in the soil, and according to presence or absence in the soil of any combination of them, so there must be a corresponding variation in the products of the soil. Then there must be just as wide a range of degeneration in the animal life living on the products of the soil, and, as I have previously shown, the starches, sugars, fats, proteids must vary. Therefore those suffering from consumption, insanity, cancer, and many other diseases are not only wanting in mineral constituents, but also in starches, sugars, fats, and proteids.

W. S. Furneaux says on page 84 of *Animal Physiology*—

"Life cannot be sustained on mineral foods alone, although these may contain all the elements required to make good the waste. Neither can life be permanently sustained by any one class alone of the organic foods.

Hence it follows that our food must consist of mixtures of these. But the various food substances we employ do generally consist of such mixtures; for instance, wheat flour contains the nitrogenous substance gluten, the non-nitrogenous substance starch, and also various mineral salts derived by the wheat plant from the soil in which it grew. Again, butchers' meat contains the nitrogenous myosin, the non-nitrogenous fat, together with mineral salts obtained indirectly from the soil."

Here it is admitted that foods must be of a normal chemical composition, otherwise life cannot be sustained, and it is assumed that foods are normal.

This assumption is the fundamental mistake of the medical profession, and can only be rectified by a recognition of the variations or deviations from the normal of which I have given instances in this chapter.

"Hunter's own words are—'Nature is always uniform in her operations, and when she deviates, is still regular in her deviations.

. . . It certainly may be laid down as one of the principles or laws of nature to deviate under certain circumstances. "The interest of this science, says Buckle, depends simply on the fact that when it is completed, it will explain the aberrations of the whole organic world.'"—*Encyclopaedia Britannica*, vol. xviii. p. 362.

I think I have made it clear that there is variation in plants and they produce corresponding variations in animals eating them.

Yet we go on defying nature, for many foods that nature would destroy by blights, etc., are brought to a so-called maturity by spraying or fumigating, to perpetuate in animal life those deficiencies already existing in these vegetable foods, by these means building up the conditions suitable to the development of disease in animal life.

CHAPTER IV

Immunity

Oxygen and Ozone

I have quoted Rindfleisch as saying that while there are many diseases having varying symptoms, there is one constant factor in all of them. Personally I am of opinion that there are many constant factors.

For instance, high temperature, inflammation, anaemia, and consequent want of oxygen with its concentrated form ozone.

It is also recognized that there are many pathogenic bacteria that cannot live in the presence of oxygen like the bacilli of anthrax and tuberculosis, not to mention others, and if there are other pathogenic bacteria that can live in the presence of oxygen, there are very few, if any, that can live in the presence of ozone, a concentrated form of oxygen.

It is fully recognized that the percentage of

oxygen permeating animal life bears a strict proportion to the haemoglobin, so that animal life having a blood rich in haemoglobin would have much more oxygen permeating its system than an anaemic animal.

Now the more oxygen there is in the system the more ozone there will be, and there can be no question that such an animal fully supplied with ozone will be much more immune to a given bacterial disease than an anaemic animal poor in ozone.

Although generally speaking anaemia is associated with an absence of iron only, I am confident that it is also due to a deficiency of nitrogen, phosphoric acid and potash, all or some, and while the haemoglobin is the great oxygen conveyer, still the more phosphoric acid and potash there are in the system the more oxygen there will be.

Another important factor in immunity is electricity, which is so closely connected with the chemistry of the animal that it is reasonable to think that an animal of normal chemical combination will be in a position to produce much more electricity than an animal chemically deficient.

"Now oxygen appears to be capable of assuming the ozonized condition under various conditions, the principal of which are the passage of silent electric discharges, and the contact with substances (such as phosphorous) undergoing slow oxidation in the presence of water."

Again, as oxygen appears to be capable of assuming this ozonized condition in the presence of phosphorus, to say nothing of iron, it is easy to understand how the normal animal would be likely to have more ozone than the abnormal.

The value of oxygen, or more properly ozone, as conveying immunity, is recognized by many authorities. Thus Dr. Henry Day, in *Ozone in Relation to Health and Disease*, says—

"The apparent connexion which exists between a deficiency of ozone in the air and the occurrence of epidemic cholera," etc., and goes on to say that "air saturated with it destroys dead organic matter with great rapidity." He adds: "There is much discussion as to what the precise nature of disease germs may

be, but be they in the form of bacteria or in any other form, ozone is potent for their destruction."

T. Lauder Brunton, in *Materia Medica*, says—"Ozone, it is thought, would be useful in destroying organisms which produce disease."

Professor Tyndall has also proved the value of ozone in destroying germ life.

If a deficiency of ozone in the air be associated with the occurrence of epidemic cholera, etc., it requires no argument to support the view that a deficiency of ozone in the animal economy will render it more or less susceptible to cholera bacillus.

R. A. Proctor, writing on ozone, mentions an experiment carried out by Dr. Richardson, who placed a pint of blood taken from an ox in a large wide-mouthed bottle. The blood had then coagulated, and it was left exposed to the air until it had become entirely redissolved by the effects of decomposition. At the end of a year the blood was put into a stoppered bottle and set aside for seven years. "The bottle was then taken from its hiding place," says Dr. Richardson, "and an ounce

of the blood was withdrawn. The fluid was so offensive as to produce nausea when the gases evolved from it were inhaled. It was subjected by Dr. Wood and myself to a current of ozone. For a few minutes the odour of ozone was destroyed by the odour of the gas from the blood. Gradually the offensive smell passed away, then the fluid mass became quite sweet, and at last a faint odour of ozone was detected, whereupon the current was stopped. The blood was thus entirely deodorized, but another and most singular phenomenon was observed—the dead blood coagulated as the products of decomposition were removed, and this so perfectly that from the new clot that was formed serum exuded."

If ozone when applied to such putrid blood can have such a revitalizing effect, how essential must it be to the living animal that it should have all the ozone in its system that nature intended it to have. I feel confident this can only be obtained by or through the aid of normal chemical functions in the body, and they will only be produced by a normal food.

I shall now quote evidence to show how

food influences immunity or susceptibility in animal life eating it.

Lecture on the Physiology of Plants, by Julius von Sachs, translated by H. Marshall Ward, F.R.S., etc., on page 326 says—

"It is now decided that all the various carbohydrates, fats, and proteid substances of the plant are derived from the starch assimilated in the chlorophyll. This is practically equivalent to saying that all the organic substances necessary for the construction of the cells and organs of the plant are to be referred to the activity of the assimilating chlorophyll, since the plant requires for the construction of cells and organs generally only these three groups of materials."

Epidemics, Plagues and Fevers: their Cause and Prevention, by Hon. Rollo Russell, on page 374 says—

"Predisposition may be hereditary or acquired, and may obviously depend on several peculiarities, such as the character and the ingredients of the blood."

On pages 374, 375, he quotes—

"Dr. H. B. Carpenter, in 1853, had come to the conclusion . . . If decomposing matters be abnormally introduced from without, or be generated in abnormal amount within the body, or if the process of elimination be obstructed, an accumulation of matters takes place in the blood, and this, by producing the pabulum requisite for the development of the poison, supplies the very condition necessary for its morbific activity. . . . In hot climates where the activity of the respiratory process is reduced by the high temperature, long marches are noticed as causing special liability to zymotic infection."

On page 376 he says—

"Famine produces an accumulation of waste products in the blood, and is likewise noted as highly favourable to the development of fatal fevers."

On page 380 he says—

"There can be no question at all that the very small differences in the blood quality are sufficient to determine infection or immunity."

On page 395—

"The serum of animals which took anthrax

readily never possessed such a strong bactericidal action as the serum of white rats which are immune. . . . Dr. Buchner ascribes immunity to proteid substances. . . . Wild rats, fed on plain bread for about six weeks succumbed to anthrax with which they were inoculated, others fed on flesh did not take it, and their spleens were found to contain an abundance of the proteids."

On page 396 Prof. Emmerich, of Munich, stated—

"That his previous experiments on swine fever had proved that in immune animals the bacilli of swine fever were destroyed not by the cells of the animals, but by a bactericidal substance present in the blood. The bacilli were destroyed almost immediately after their introduction under an immune animal's skin."

On page 398 he says—

"Dr. Klein observed that frogs and rats were insusceptible to anthrax, but that they could be made susceptible by various means, indicating that their normal resistance was due to certain chemical conditions of the blood."

Bacteria, by Geo. Newman, M.D., F.R.S.,

Edinburgh, Demonstrator of Bacteriology in King's College, London, says, on pages 269, 270—

"Whatever may be said hereinafter with regard to the power of micro-organisms to cause disease, we must understand one cardinal point, namely, that bacteria are never more than causes, 'for the nature of the disease depends upon the behaviour of the organs or tissues with which the bacteria or their products meet.—VIRCHOW.'

"The normal living tissues have an inimical effect upon bacteria. It has been definitely shown that the blood fluids of the body have in their fresh state the germicidal power (alexines) which prevent bacteria from flourishing in them. Such action does undoubtedly depend in measure upon the number of germs as well as their quality, for the killing power of blood must be limited. . . . Buchan has pointed out that the antagonistic action of these fluids depends in part possibly upon phagocylosis, but largely upon a chemical condition of the serum. . . . The blood, then, is no friend to intruding bacteria. . . . All the foregoing points

in one direction, namely, that if the tissues are maintained in normal health they form a very resistant barrier against bacteria."

The Origin and Growth of the Healing Art, by E. Berdoe, L.R.C.P., Edin., M.R.C.S., Eng., etc., on page 475 says—

"It has been found that men and animals may be insusceptible to infective disease by natural immunity. Not all persons subjected to exposure to epidemic diseases contract them."

The passages above quoted show that it is admitted that the proteids are fatal to pathogenic bacteria, and that the carbohydrates, fats, and proteids of the plant are dependent on the chlorophyll.

It is well recognized that the chlorophyll of the plant varies considerably, therefore the carbohydrates, fats, and proteids of the plant must vary in a like proportion, and as animal life can only obtain its carbohydrates, fats, and proteids through the vegetable food eaten, they must vary consequently in the animal

and in mankind. Herein lies the susceptibility or want of immunity in animal life to disease.

As haemoglobin is allied to the proteids and a red modification of chlorophyll, it follows that the haemoglobin of the animal varies as the chlorophyll or chlorophyll products vary in the plants eaten. In other words, the carbohydrates, fats, and proteids of the animal vary as the haemoglobin, which is proved to vary by analysis ; see under Variation.

It is recognized in most if not all bacterial diseases that there is a deficiency of carbohydrates, fats, and proteids, and that proteids when present are fatal to these bacteria.

Therefore as haemoglobin, to all intents and purposes, is a proteid, it must be fatal to pathogenic bacteria when present in normal quantities.

It is recognized that there is always a deficiency of haemoglobin in these bacterial diseases, but it is thought by some that the bacteria cause the deficiency, that is, that the bacteria eat up what is a poison to themselves, which is, as far as I know, contrary to all the

laws of nature, and which is proved to be incorrect, as rats which contained an abundance of proteids, remained immune to anthrax, while other rats wanting in proteids died of the disease.

While scientists of undoubted standing consider there is a chemical difference between the blood of animals immune to and those susceptible to a given disease, I think the evidence is now fairly strong in support of the vital point that pathogenic bacteria can only attack animal life when more or less deficient in haemoglobin, and what follows as a natural sequence, in carbohydrates, fats, and proteids.

Of course, how far the bacteria can and do produce a further deficiency through the eating up of devitalized carbohydrates, etc., of a blood, and tissues that are already so deficient as to allow them to grow, is another question. It is thought by some that the killing power of blood must be limited. Personally, I think the killing power of a normal blood on pathogenic bacteria is unlimited.

For instance, there were a few oxen during the rinderpest epidemic in South Africa that

could not be made to take the disease during a period of two to four months, although during that period they had from 200 to 300 cubic centimetres of virulent blood injected under the skin; and when it is remembered that one drop of virulent blood is more than enough to give an animal the disease, then these animals had enough to give them the disease thousands of times; yet it had no effect on them, either as far as the eye could see or the thermometer indicate.

These animals were in various bile stations, and any one wishing to learn how to use the hypodermic syringe was permitted to experiment on them, yet they never suffered from the constant inoculation. Hence we can only conclude that they were immune to an unlimited extent.

Again, doctors and nurses in consumptive hospitals must, in the course of twelve months, take in by the mouth and nose myriads of tubercular bacilli, yet the large majority of them never take the disease.

So that the blood of these people has plenty of killing power, and it is the same in other diseases.

One farmer told me he injected hypodermically half a pint of virulent blood into an animal without the least effect, and I was pointed out two brothers one of whom had had malarial fever twelve times, and the other brother not once, although both brothers were living in Rhodesia under identically the same conditions.

Mr. Hugh Clifford, in *M.A.P.* of December 22, 1900, says—

"The miasma which rose from the inky waters by night racked my fellows with fever, and more than once I have had to cook rice for the whole crew while the boat remained anchored to the bank, because no one of them was well enough to undertake that or any other duty. Yet I passed unscathed, and then and afterwards during the whole of my service in the Malay Peninsula, I never came in for the 'touch of fever' with which almost every white man in the East is destined to make acquaintance."

For years I have been advocating the analysis of immune and non-immune blood in

various diseases, but if the public knew the exact truth of the subject it would so simplify it that every intelligent person would know all that was required.

As it is recognized that animal life must take the proteids into its system already formed, so the proteids must vary in the animal as they vary in the vegetable food eaten, and as the range of variation in plant food is very great, so the range must be correspondingly great in animal life.

It is also recognized that proteids are fatal to pathogenic bacteria, so that animal life rich in proteids would be highly immune to pathogenic bacteria, while animal life poor in proteids would be very susceptible to disease.

So that the difference between immunity and susceptibility to disease is the difference between a good supply and a poor supply of proteids in the system, this depending, as I have shown, upon the food and ultimately upon the soil from which the necessary iron and nitrogen must be obtained.

As practical evidence it is well known in South Africa that injections of bile rendered cattle immune to rinderpest.

At the same time it was not every bile that would render animals immune.

It had to be what was considered a healthy bile, and even that was not always successful.

In fact, bile taken out of one jar, when hypodermically injected would render one lot of animals immune and would have no effect on others. Now no one will doubt that bile would contain more or less iron and proteids, and that the efficacy of the bile would vary as the iron, and consequently the proteids contained therein.

One can also understand that the iron and proteids would vary in the blood of different animals, so that the efficacy of the bile inoculation would vary as the iron and proteids in the bile and in the blood of the animals inoculated.

CHAPTER V

EFFECT OF FOOD ON ANIMALS IN CONNEXION WITH DISEASE AND HEALTH

It is a well known fact that cattle coming to the Karoo from the Redwater country, on the coast of South Africa, even though they may contain within themselves the germs of redwater, never either develop the disease or communicate it to Karoo fed cattle. Indeed, a beast from the coast actually suffering from redwater may be allowed to run with Karoo fed cattle without the slightest risk of their catching the complaint. Yet on the coast country itself cattle suffering from redwater will spread the disease far and wide through their urine.

No country that I ever heard of in the Karoo has ever become infected in any way with redwater, so showing that the bacteria or fungi of this disease cannot live in the Karoo soils.

The question then is what is the difference between these two soils? Another significant fact is that in the part of the country where redwater is prevalent, not more than two per cent. of rinderpest infected cattle, prior to the introduction of inoculation, recovered; on the other hand, where redwater is unknown, of the animals treated with virulent rinderpest blood, with the object of obtaining immunized blood, the percentage of recoveries was as high as sixteen.

Now I have shown that the blood must vary in quality as the food, hence it is to be expected that food is of better quality on the Karoo than the coast herbage, and that this is so is shown by the fact that Karoo stock of all kinds are healthier than the stock reared on coast farms.

It is recognized by the Cape experts that there is something wanting in the coast herbage, but what that something is has never been determined, although we have the fact that sheep having iron on the coast farms are much healthier and suffer less from the various complaints affecting these sheep, than farms where they do not have iron.

Therefore one has good reason for saying that at least one of the deficiencies in the coast herbage is iron.

In this same coast country it is recognized that while a few years ago sheep had plenty of yolk in the wool, to-day it is a noticeable fact that the wool is very deficient in yolk, so much so that it is a matter of common talk among the farmers.

In *Sheep*, by Youatt, under "Yolk," he mentions that a French chemist had analysed the yolk taken from hundreds of sheep, and in every case had found various forms of potash, and the chemist comes to the conclusion that since potash is so constantly found in the yolk, it plays some important part in it.

The Cape Agricultural Department has analysed a very large number of samples of soil, and in all that I have seen, there is a marked deficiency of potash.

There can be no doubt that this deficiency has been brought about by the quantity of potash carried off by the wool during the many years the sheep have been grazing on this land, and further by the system in general use, for protection against jackals of kraaling or

yarding the sheep, the result of which is that a large percentage of the potash, to say nothing of other plant foods, has been deposited in heaps sometimes of huge dimensions; as compared with other countries where the sheep remain at large and their droppings are more or less evenly distributed over the surface of the pasture.

HEARTWATER

Heartwater, I believe, is a disease quite unknown in any part of the world but South Africa, but it is interesting as a very insidious form of bacterial disease.

It is prevalent in the eastern side of Cape Colony—the Kei river, I think, is at present the northern limit of the country devastated, extending down the coast some distance beyond Port Elizabeth, which means over 200 miles of coast line and extends inland from forty to fifty miles up to as much as 100 miles.

So, after excluding patches of non-infected country, there must be some 7,000,000 acres of the best pastoral country in South Africa rendered almost useless for carrying angora

goats or sheep. At the same time it is very unhealthy for all other kinds of stock, cattle being very liable to lung sickness, redwater, (some taking heartwater), and to diseases locally known as gall sickness, and bush sickness, while calves are very liable to a disease known as liver sickness.

It is also very unhealthy country for horses, many dying of horse sickness, which Dr. Edington, the Government Bacteriologist, says is very similar in internal appearance to heartwater and biliary fever.

In all these diseases more or less the same symptoms are found, namely, either a dark or black blood or a thin and watery one, in either case more or less non-coaguable, internal organs inflamed with high fever, and in heartwater the internal fat, instead of being a snow white, as in the case of healthy sheep, is more or less dark and dingy, and of so abnormal appearance that unless one has seen the animal opened it is hard to believe that it could have been taken from an animal.

Heartwater, for various reasons, is the worst stock disease in Cape Colony. It has been definitely known as a disease for about thirty

years, but some farmers think it existed prior to that date, only it had not been diagnosed. It first made its appearance on the coast country, and has been slowly but surely spreading till it has devastated the tract I have described.

There are many different opinions as to the nature of this disease, but I think there can be no question that it is of fungoid origin, and is indigenous in the grass and soil of the country affected. It is quite certain that if you take sheep or goats from non-infected country and place them on infected veldt, a high percentage of the animals will die of the disease, an odd one occasionally as soon as the ninth day after the change of pasture, while at the end of three weeks you may have as many as 5% dead in a day, and this number in bad pastures may be kept up daily for weeks if the sheep are allowed to remain so long.

The death rate, however, will decrease rapidly as soon as the sheep are placed on healthy veldt.

One peculiar feature of this disease is that in any given piece of country the disease may be very bad for a number of years, when, with-

out any apparent reason, there will be almost a complete cessation for one or more years.

Sooner or later, however, the disease will break out again, till in the end no sheep or goats can be kept on the farm.

In proof of this I may state that there are farms to-day that can be bought for ten shillings per acre, which, if they would carry sheep, would bring forty shillings per acre in the open market.

It is evident, therefore, that the capital value of this piece of country is some £10,000,000, representing an annual income of £500,000, less than it would be if there were no heart-water.

As to the cause of the disease, Veterinary-Surgeon Soga is strongly of opinion that the mimosa (which is very common over a large portion of Cape Colony), which is steadily spreading and grows very thickly in some of the worst heartwater districts, exhausts the soil, which no doubt it does, and so impoverishes the herbage.

Another cause of impoverishment, which I have already mentioned, is the yarding of the animals at night, which produces huge stacks

of manure. I have seen one that was quite fifteen feet high. This may appear like an exaggeration, but seeing is believing, and one can understand what an exhaustion of the soil must have taken place to produce such a mass.

Dr. Edington and Veterinary-Surgeon Soga both say there is something deficient in the herbage. Is it not likely that this deficiency has been brought about by exhaustion through the mimosa and the mineral constituents deposited in the kraal heaps, and which would be of much more value on the veldt, of which I think there is no question ; then there must be a corresponding deficiency in the blood and tissues of the animals eating this food. This will also account for the similar internal appearance of animals suffering from various diseases all grazing on approximately the same pasture.

In other words, the same deficiency in the veldt produces the same deficiency in all the animals feeding on it.

This view of the case is further confirmed by a cablegram appearing in the *Westminster Gazette* as this book goes to press which reads as follows—

SOUTH AFRICAN HORSE-SICKNESS.

"The newly formed South African Association for the Advancement of Science met in Capetown yesterday. Dr. Edington delivered a lecture on animal diseases, in which he showed that the material form of horse-sickness, with parasites in the blood, and several other stock diseases which have not hitherto been defined, are the same malady existing in relative virulence for particular species."—*Reuter*.

If this be admitted, it would seem that the most practical way of coping with this disease would be to attempt to restore this deficiency to the veldt, and from a financial point of view any reasonable expenditure would be thoroughly justified, seeing the large expanse of otherwise valuable land which is to-day yielding practically no revenue.

As to how the disease spreads there is nothing absolutely definite, but there is no doubt that animals dying and decaying on a given veldt do cause some pastures to become infected; but this does not always apply, for there are many cases where sheep dying of the disease have been placed on healthy country

year after year without causing it to become infected with heartwater fungus.

At the same time, you will frequently find a clean piece of country first became infected shortly after a number of animals have died and decayed thereon; in fact, the liability to infection depends on the chemical state of the herbage.

Some veterinary surgeons and farmers think ticks are the means of spreading the disease, others think not; but from the evidence it appears that it is quite as probable that ticks spread this disease, as that mosquitoes spread malaria.

It must be remembered, however, that they are simply a means of spreading the disease and not the cause of its existence, any more than the eagle is the cause of the dying stag which it will hasten the death of.

There is one fact in connexion with this disease, namely, that it may be virulent on one side of a fence and the sheep not suffer on the other side. In cases of this kind it was noticed that on the side where the sheep were not suffering from this disease, it was very heavily stocked, so that the herbage was

short, while on the infected side it was lightly stocked, and the herbage proportionately longer. Further, when this was noticed and the infected ground heavily stocked, the disease was reduced to a minimum.

How far this might be confirmed by extended experiments I do not know, but even if it was found infallible, it never could be of more than partial value, as the mortality would be too high in droughty periods.

Another feature of the disease is that it appears quite indifferent to change of climate, as it is just as virulent on the sea coast with a warm, moist climate as in the Karoo, where it is very hot and dry in summer and cold in winter.

The internal symptoms are distinctive, the one from which it takes its name being very marked, namely, a serous or watery fluid in the pericardium or sac surrounding the heart, with a varying quantity of watery fluid in the chest cavity, ranging in colour from straw to blackish red. When it is a straw-coloured fluid, you will frequently find a yellowish jelly in the pericardium and chest cavity having every appearance of serum, and in some cases

when it is a blackish red watery blood, I have noticed the chest cavity filled with it. In cases where I have had diseased animals killed, and found the chest cavity very full, it was noticeable that very little blood came from such animals, suggesting the idea that it is a dropsical disease, the disintegration of the blood being brought about by the fungoid growth instead of being caused by extreme anaemia as in the case of dropsy.

Many farmers think there are two forms of heartwater, the one I have so far described, which is more or less acute, and another which is protracted and shows considerable swelling round the head, from which can be drawn the same watery fluid.

In these cases, as far as I know, there is no heartwater, but large numbers of wire-worms can be found in animals dying of it, as well as in animals dying distinctly of heartwater. And as authorities writing on wire-worms say they produce anaemia, it is clear that heartwater is connected with anaemia, and therefore with an impoverished blood.

Many farmers assert they can cure wire-worm in lambs by giving them succulent food, which

would improve the quality of the blood; so if improving the blood cures lambs of wire-worms, I fail to see how the worms can produce anaemia; In fact, I should say anaemia is the predisposing cause that brings about the existence of the parasite. Remove the cause, poor blood, and you remove the parasite. In the same way I would say the predisposing cause in heartwater is anaemia. Remove this, and you remove the predisposition to the disease.

I have previously mentioned that Drs. Edington and Soga say there is something deficient in the pasture, and it is reasonable to think this deficiency is the origin of the anaemia. Heartwater varies in duration from a few hours to days, and in some cases weeks, but the average time in which it is fatal would be from thirty to forty hours. In acute cases I have noticed the blood is very thin, with little or no coagulation, while in cases of a lingering nature a much higher percentage of the blood coagulates, and in all cases noticed the blood is either very dark or very pale, but never of the bright red colour common to blood which coagulates readily. There are those who will

say the disease produces this abnormal colour, but if they will notice the blood of any number of animals slaughtered for the butcher, they will find a very considerable range of colour in the blood, while not one of these animals will show any sign of disease either by ocular observation or by the thermometer.

Yet if their view were correct, the colour of the blood would be an indication that they were suffering from some disease and therefore unfit for food.

As a matter of fact, they are diseased, inasmuch as their blood and consequently their tissues are abnormal, and no doubt in such a state that if pathogenic bacteria were injected into them, they would develop some one recognized disease according to the bacteria or fungus injected.

In the case of heartwater I have noticed that animals that have been on infected country for months, remaining free from any disease all the time, yielded when slaughtered a blood of a bright red, coagulating readily into one solid clot, which clot, when broken, showed the same constant colour right through. This is an important point, because you will find the blood

of some animals coagulating and showing a bright red on the surface, but when broken it is black on the inside.

Other bloods I have noticed show red and black streaks intermingled, others all black and others all red. I have thus had ocular demonstration that considerable variation exists in the blood of animals, of which the truly normal is the one showing entirely red.

In discussing the subject with individual farmers, one told me he had noticed in drawing blood from cattle to be injected into others, as a cure for rinderpest, after it had been defibrinated, that much better results were obtained from a red blood than from a dark one, and so striking was this fact that afterwards he would never use any but a red blood. At the same time it must never be forgotten that there are degrees of redness.

Another African-born farmer, over sixty years of age, says he has always noticed in drawing blood from horses or cattle that if the blood was dark, these animals were always more liable to disease than those having a brighter blood.

With this evidence before us I think it

is clear that we should try to give all animal life a bright red blood, and the only true way of doing this is to be sure that the food is such as will produce the blood required, and this I have tried to make clear in previous chapters.

It may be asked why this disease should not be treated by hypodermic injections of iron and nitrogen. I have no doubt that in heart-water, and no less in redwater, and rinderpest, an injection of dialyzed iron would be beneficial, but there are difficulties in the way of doing it on a large scale, owing to the discharge of pus which leaves an open wound, which would be immediately attacked by the ordinary fly, and to keep these wounds healthy while healing, when it comes to a question of a large herd, is outside the region of practical stock farming.

I have not tried an injection of either nitrate of soda, or potash, but I have no doubt it would have the same objection, namely, an open wound.

With regard to sheep, an injection of iron is distinctly beneficial, and no doubt does check heartwater, especially in combination with

phosphate of potash, though this requires to be very carefully administered in order to avoid blood poisoning with carbonic acid, when a low percentage of this acid is present.

But in connexion with heartwater I believe it to be such an insidious disease that only the proteids will secure immunity, and the only way to do this, at least in a practical way, is to manure, say, two or three hundred acres with iron, phosphates, and potash, fence it off and graze a reasonable number of sheep on it, and when their blood has become something like normal, inject the requisite dose of this normal blood, when defibrinated, into the sheep that are to graze on infected country, at the same time giving them perchloride of iron, nitrate of potash or saltpetre, and bone meal mixed with salt, so that they can take what they want daily. If this does not keep them healthy, then a considerable area of each farm will have to be manured, and this is rather a large order.

But there is evidence to show that iron and nitrates mixed with salt is distinctly beneficial, as Mr. Walter Edmonds, of Kei Mouth, South Africa, kept his sheep very healthy by giving

them such a mixture, and his farm is one of those in the infected area.

Again, a large number of farmers in the Burghersdorp district keep their sheep healthy by giving them salt and nitrate of potash, and I have heard of other farmers who have used saltpetre with the same result.

There are also farmers who say they keep their cattle free of redwater by giving them salt and iron. No doubt it would be better if saltpetre were added to this.

As further evidence, Mr. Steyn, of Bloemfontein Farm, Upington, Gordonia, South Africa, writing on February 22, 1898, on rinderpest in his district, says—

"It has been proved beyond dispute that the spread of the disease is most gradual in this district, and I could name numerous instances where healthy cattle were put into the same kraal with sick ones for two or three nights, and that they were quite well months afterwards. In conclusion, I may state that the cattle from this farm were much tougher against infection, and on the whole took it in a milder form than other cattle which were treated

in the same manner. This applies to artificial infection at late Bile Station.

"Breed of cattle, bastard Herefords.

"Yours faithfully,

"(Signed) R. W. F. STEYN."

What appears to me to be the reason for this immunity is that on this farm there were mineral springs containing iron, and it was from these springs that the animals drank their water. Consequently, there would have been a higher percentage of iron in the blood of these animals.

And to show that animals require iron, I have seen mules licking rusty iron, just as thousands of people have seen horses licking salt.

The following cutting from the *New York Herald* is interesting collateral evidence, especially taken in conjunction with the fact, which I have referred to on page 126, that sugar extracts iron from the soil.

"EATING RAILWAY IRON

"Iron for the blood has evidently been prescribed for the quails of Florida; at least, these birds are eating steel rails on the tracks

of the sugar belt near Runnymede. The report, which is well authenticated, does not charge the quails with actually swallowing the rails, but it does say that they pick away their particles wherever they find a rusty spot where they are loosened.

"From several points in the State comes the report of holes found in the steel rails, and in cases they are large enough to seriously weaken the material. Where a rusty spot starts and is picked out, it naturally holds moisture, continues to rust, to be again picked at, and so the work of destruction goes on.

"Railway engineers really believe that the quails take the iron tonic because they are not well, and find that it relieves their distress."—*New York Herald*, December 23, 1900."

FLUKE

In *Sheep*, by Youatt, on page 450, under "Fluke, or Rot," we read—

"The ova are continually swallowed by the sound animals and the diseased; but it is only when the fluids are altered, and sometimes essentially changed, and the condition of

the digestive organs is materially impaired, that their appearance is favoured, or their multiplication encouraged. They resemble the birds of prey, that hasten the death and the demolition of the fallen deer, but who are not concerned in bringing the animal down."

And on page 453, after giving much evidence on the subject, the author says—

"Then there is something more than moisture necessary for the production of the rot."

Mr. H. Newton Hart, of Mountain Top, Cathcart, South Africa, says—

"For three years prior to 1890 I used to lose 100 sheep out of my flock of 1,000 each year from fluke.

"I then gave them sulphate of iron, mixed with salt, every spring, since when I have not lost any sheep from fluke.

"The sheep only appear to care for the salt and iron when the grass is green and sappy. For the last two years we have been suffering from drought, when I find the sheep do not

care for it, and consequently have taken very little during this period, and I now find fluke reappearing in the liver of sheep slaughtered. This is in the year 1900."

Can one produce stronger testimony in support of keeping the animal healthy to enable it to resist this disease.

To my mind there can be no question that the herbage is chlorotic, and if the land was manured with, say, 100 pounds of oxide of iron, the pasture would not only be improved, but there would be no sheep lost through this disease, to say nothing of other diseases.

TUBERCULOSIS

In tuberculosis again the analysis of milk given on p. 48 shows clearly the *grave* chemical deficiencies which go with a defective haemoglobin, and as it is recognized that milk is a product of the tissues, it is clear that an animal suffering from tuberculosis is not obtaining from the food eaten the requisite chemical constituents. In other words, in this, as in the diseases I have previously referred to, chlorotic food is at the root of the matter, and the proper

manuring of the pasture is the only certain cure.

Therefore indirectly, if not directly, the milk of a tuberculous cow tends to set up the conditions suitable for the growth of the human form of the disease.

The same argument is applicable to human beings eating the flesh of an animal liable to or suffering from this disease.

And as it is recognized that milk is a product of the tissues and not directly of the food, it follows that the tissues of an animal liable to or suffering from tuberculosis are deficient in fats and nitrogenous substances. It therefore follows if a human being were to live largely on the flesh of animals so impoverished, that the tissues, blood, etc., of the said human being would become poor in fats, nitrogen, etc.

In fact, just as a good quality of grain is sixteen times superior to a poor grain in its feeding qualities, so is the flesh or milk of an animal immune to tuberculosis, or other bacterial disease, infinitely superior in its feeding properties to the flesh or milk of an animal either liable to or suffering from tuberculosis or other bacterial disease.

To make the case the clearer, we will suppose there are two farms, one having a thoroughly rich soil, and the other a very poor soil, and that a given number of animals were kept through two or three generations on each farm. It is easy to see that the animals reared on the rich soil would be vigorous healthy animals, containing the maximum of haemoglobin, fats, sugars, and proteids, while the animals reared on the poor soil would have become anaemic, wanting in fats, sugars, and proteids, with correspondingly weak constitutions.

Taking these two lots of animals, does any one doubt which would be most likely to resist disease, let it be tuberculosis or other bacterial disease.

One important point in connexion with all bacterial disease is that it is recognized that all classes of bacteria can only live on foods corresponding in chemical composition to themselves, which axiom equally applies to all forms of life, including man.

With few exceptions, pathogenic bacteria belong to that class of plants known as the fungi.

The distinct chemical difference between

fungi and what we look upon as ordinary plants, is that the fungi contain no iron or nitrogen, while these constituents are essential to ordinary plant life.

It is known that iron and nitrogen are fatal to fungi, therefore the more iron and nitrogen animal life takes up in its food the more likely it is to be immune to bacterial diseases.

(1) Because it will have a richer haemoglobin, which takes more oxygen into the system and discharges from the system more carbonic débris, which is a natural food of most if not all pathogenic bacteria.

(2) Such a food will contain more carbon, so that there will be more sugars, fats, and proteids.

(3) In a blood rich in haemoglobin, there being more oxygen, it follows there will be more ozone, and ozone is fatal to pathogenic bacteria.

(4) Proteids are considered fatal to pathogenic bacteria, and as there would be more proteids in a blood rich in haemoglobin than in an anaemic blood, it follows that a blood rich in haemoglobin would be more immune to pathogenic bacteria than an anaemic blood.

Therefore the conditions of a normal or healthy blood tend to immunity, while the conditions of an anaemic blood tend to disease, and the variations in disease are produced by corresponding variations in the food eaten.

In other words, animal life living on normal or the best foods, has its whole system worked as nature intended it should be worked.

And as the food degenerates from the normal, so do the functions of animal life degenerate, so that the greater the degeneration of the food the greater the degeneration of the functions, and the degree of variation in de-degeneration accounts for the degree of variation in the virulence of a given disease in any animal attacked.

To show that these views work out in practice, I will quote a few lines from the *Cape Agricultural Journal*, of May 9, 1901. The Editor, writing of Rambouillet sheep imported by Mr. Rogers, of Glencairn, Cathcart Division, South Africa, says—

" The least I can say is that I am more than satisfied with them ; in fact, they have in every way exceeded my most sanguine expectations.

"Although they have been running on the grass summer and winter and never housed, they have never developed any symptom of disease of any kind. Their progeny are making larger carcases and producing heavier fleeces of wool, than the imported parents.

"EDITOR."

The reason I have quoted the above is because all over this farm and one or two adjoining farms, ironstone crops out on every ridge. I have been over this farm with Mr. Rogers, and you can see the disintegration of the ironstone going on, so that the soil on these two or three farms, and consequently the grasses, must be rich in iron; but the benefit cannot extend far, as, the country being all hills, the area is confined by rivulets.

Mr. Rogers told me that in the eighties, when sheep died by thousands in all the adjoining country, the sheep on these particular farms remained free of disease.

These facts are to some extent confirmed in England by Dr. Somerville, then Professor of Agriculture at Cambridge University, who experimented with various manures on pasture

and found that sheep grazing on land manured with basic slag increased in weight faster than sheep grazing on similar pasture manured with phosphates, and slag contains about 18% of iron.

In conclusion, I can only reiterate what I have already said : manure the land with iron, (nothing has been done in this direction in the history of agriculture in Great Britain, or any other part of the world), phosphates and potash, and I am sure the predisposition to tuberculosis in dairy stock will be removed. And there is no question that if you remove bovine tuberculosis, you remove a big factor in human tuberculosis, quite irrespective of the question as to whether the bovine bacillus will grow in the human being or not, but simply from the fact that either milk or meat suitable for the growth of this bacteria, if consumed for any length of time by human beings, must simply lower their blood and tissues to such a level as will admit of the growth of the human form of the bacillus.

CHAPTER VI

HUMAN DISEASES

CANCER

In *The Essentials of Chemical Physiology*, by W. D. Halliburton, M.D., F.R.S., page 59, the following table gives some important analyses of human bile :—

Constituents.	Fistula bile (Case of Cancer) Yeo and Herroun.	Normal bile (Fverichs).
Sodium glycocholate . . / Sodium taurocholate . .	0·22	9·14
Cholesterin lecithin fat .	0·038	1·18
Mucinoid materia pigment.	0·148	2·98
Inorganic salts . . .	0·878	0·78
Total solids. . . .	1·284	14·08
Water (by difference) . .	98·716	85·92
	100·000	100·000

Here it is clearly proved that there is a

great difference in the composition of a healthy or normal bile and of the bile of one suffering from cancer.

I have shown in the chapter on Variations, p. 51, that the bile contains a distinct quantity of iron, which probably has its origin in the iron set free from the haemoglobin.

There is no doubt that iron in the above analyses would be found in pigment; and it is easy to see there would be much more iron in the pigment of a healthy bile than in that of a cancerous bile, and it is thought that this iron is set free from the haemoglobin, in which case it is evident the individual having a normal bile will have something much more like a normal haemoglobin than the individual having a cancerous bile.

This view of the case is supported by the views of medical experts on fatty degeneration in cancer.

Drs. Fagge and Pye Smith, writing on fatty degeneration, say: "The reduction in the amount of oxygen supplied to the tissues seems to be the cause of one of the most striking of the morbid appearances which are found in the bodies of those who have died in a state of

extreme anaemia, namely, granular or fatty degeneration of the heart. In 1873 this characteristic appearance of the heart was observed in a woman who died of cancer in the breast, and in many other cases. Also in phthisis the cases of anaemia are numerous."

Drs. Fagge and Pye Smith admit that anaemia is closely allied to phthisis, fevers, syphilis, rheumatism, cancer, Bright's disease, and malaria.

We have here a distinct statement that there is a deficiency of oxygen and that there is anaemia in those suffering from cancer, so that in such cases there is a deficiency of iron and nitrogen in the blood; in other words, a poor haemoglobin; and there being a defective haemoglobin means a reduction in the supply of oxygen to the tissues, hence fatty degeneration.

So we have it proved on the one side by analysis that there is a deficiency of iron in the system, and on the other by medical experience, which leaves no question, that cancerous patients have thoroughly impoverished systems, and consequently they are deficient in fats and phosphoric acid.

This is further shown by analysis in the case of lecithin, where the healthy individual has very many times as much phosphorized fat as the cancerous patient. More evidence on the thoroughly devitalized state of the patient is scarcely necessary.

As to treatment, many people will remember the noise that was made some years ago with regard to a decoction of cinnamon being a cure for this fatal disease ; but on a more exhaustive trial it was found not to be reliable.

Is it not likely that the variation in the efficacy of this treatment was due to a corresponding variation in the chemistry of the cinnamon used ?

At the present moment molasses is being put forward as a specific.

Now, analysis shows that the principal mineral constituents in the juice of sugar-cane are potash, soda, lime and iron.

These minerals will numerically be found in a larger degree in the treacle, as they are missing in the refined sugar, and it may well be molasses will prove an excellent means of supplying the missing chemicals in the case

of cancerous patients. In conclusion, I would say if those suffering from cancer could only be fed on foods like apples, milk, cream, spinach, cinnamon tea if you like, and other foods, all produced on scientific lines, so that the foods should contain the maximum of normal ash constituents, and consequently the maximum of normal proteids, then I think there would be no difficulty in curing cancer. At least, there is evidence in support of this view of the case, and in such a terrible disease it is worthy of a thorough trial. The only unfortunate part is that it is not applicable to urgent cases, as it would at least take several months before such foods could be produced with any confidence in their normal chemical constitution.

LEPROSY AND FOOD

Any one interested in leprosy will find much information on the subject in the report of the Leprosy Commission held in India during 1890–91, which contains 104 reports on the treatment of this disease. From these I have selected the methods of treatment which appear to have been most successful. The leading feature of the four appears to be

simply the building up of the tissues and consequently of the constitution of the patient by giving iron, nitrogen, phosphoric acid and carbohydrates, by the means of iron, cod-liver oil, quinine, strychnine and gurgum oil, together with the best food obtainable.

This system of treatment is further confirmed by Drs. G. A. Hansen and Car Loft in their work on *Leprosy*, in which they mention a Dr. Danielssen, "who spent half a century in trying to cure leprosy."

This doctor says—"If the patients were badly nourished, he first administered quinine, iron, cod-liver oil and nutritious food; and when the patient's condition was satisfactory, he gave ten grammes salicylate of soda four times a day, etc."

Quite recently Mr. Jonathan Hutchinson read a paper on the "Present State of the Leprosy Question in India and Ceylon" at a meeting held in connexion with the Prince of Wales' Leprosy Fund (1890), where he stated that—

"He held the firm conviction that leprosy was, in the main, a food disease; . . . and that

the one article of food which was to be suspected was badly cured fish eaten without being sufficiently cooked."

Without having an analysis of fish it is not possible to state positively; but from a common sense point of view, it appears likely that fish would be very deficient in iron and chemical compounds more or less governed by this mineral—at least, the average fish is wanting in fats, and lepers are wanting in the same. In any discussion of this question it is important to consider the conditions of life of the races most subject to this disease. In the old world it is specially rife in India and China, where the poorer sections of the population are undoubtedly insufficiently nourished. The staple food of the masses is rice, a cereal which is now recognized as producing a physical condition suitable to the development of this disease.

In *India in* 1887, R. Wallace, Professor of Agriculture and Rural Economy in the University of Edinburgh, p. 207, says—

"It has long been a matter of surprise that

paddy (rice) should grow year after year in the same soil for generations without the land being manured.

"This seems to be accounted for by the following facts: That rice is notoriously deficient in mineral matter and nitrogen, or, in other words, the substances which ordinary crops take away from the soil."

In *Food*, A. H. Church, Professor of Chemistry in the Agricultural College of Cirencester, says, on page 76, under "Rice"—

"It is said to be the main food of one-third of the human race. Alone, however, it is not a perfect food, being deficient in flesh formers and mineral matters."

Report of the Leprosy Commission in India, 1890–91, under "Diet"—

"Since the earliest days in the history of leprosy the greatest influence in the aetiology of the disease has been attributed to the defective or bad dietetic conditions. That food

should have a specific effect in the aetiology of a chronic disease is *a priori* quite within the bounds of possibility. The views of many of the older authors would not be misrepresented by stating that they claimed for diet only a direct effect in the establishment of a specific predisposition."

In *Medicinal Plants*, by Bentley and Trumen, vol. iv. No. 291, on "Rice"—

"From a comparison with other cereal grains, rice contains a larger proportion of starch, much less nitrogenous substances, and less of fatty matters and inorganic constituents, and is less nutritious than wheat and the other cereal grains in ordinary use, from the fact already noticed."

In *Encyclopaedia Britannica*, vol. xx., p. 539—

"Payew gives only 7% of gluten in rice as compared with 22% in the finest wheat, 14% in oats, 12% in maize.

"The fatty matter is also less in proportion than in other cereals. Rice, therefore, re-

quires to be combined with fatty and nitrogenous substances, such as milk or meat gravy, to satisfy the requirements of the system."

From the foregoing evidence it is clear that leprosy is a disease due to an impoverished state of the system, and that the impoverishment is brought about by living largely on rice, fish, and possibly other cereals that are wanting in iron, nitrogen, phosphates and the surrounding carbon compounds which are governed by these foregoing mineral constituents.

I have pointed out that it is through the mineral matter of the plant, especially the iron, that the sugars and fats are produced in the said plant, so that cereals like rice, wheat, etc., containing little or no iron, would be more or less deficient in fats and sugars.

It appears to be fair presumption that the prevention of leprosy, one of the food diseases, can be obtained by improving the natural food of the people. For if the mineral matter usually found in plants, together with the

fats, etc., that follow in a natural sequence are found to be the best medicinal treatment, then it follows that the prevention will be brought about by feeding the people on foods rich in mineral matter, "which are sixteen times as rich in fats and other properties, as foods poor in mineral matter." (Prof. Tanner.)

Although I have only mentioned rice and wheat, I have already discussed the question of variation in the chemical constituents of various food stuffs at considerable length, and need not go over the ground again.

One can obtain samples of any food product that are very deficient in their mineral constituents, and consequently abnormal in their carbon compounds.

The truth is that while the question of diet has, in theory, long received the attention of the medical profession, it has, in practice, mainly resulted in the forbidding of certain articles of food as containing ingredients such as starch, sugar and others considered to be deleterious to the patient. In other words, the application of the dietetic theory has been mainly negative. Where, however, cer-

tain foods have been ordered, it is usually considered sufficient to specify the food, without consideration of the fact that its chemical constituents vary, as I have elsewhere shown, to an enormous extent, and any recognized want of the patient's constitution is supplied by drugs.

Report of Leprosy Commission in India, 1890-91, p. 333—

"Foods must necessarily modify the constitution of the tissues, and may do so in such a way as to prepare them to respond at once to the introduction of microbes against which they would have proved refractory or insusceptible."

On the same page, Dr. E. Klein says—

"Insusceptibility of the tissues is, as is well known, considered by some authorities to be connected with, if not wholly dependent on, the chemical nature of the tissues; so that while the tissues are normal or in full vigour (if the phrase may be allowed for the purpose of illustrating my meaning) a particular microbe getting access to them fails to thrive

—cannot, so to speak, overcome the inimical action offered by the tissues. . . . This power of resistance of tissues can, however, be greatly reduced, or even abolished, by certain means, such as depression of their vitality."

Now, it is a noticeable fact that no medicinal treatment is a success in leprosy, the reason being that in this, as in many other diseases, the stomach is not strong enough to assimilate the required minerals in their crude form, and their administration, therefore, does more harm than good by further upsetting the stomach, and rendering it incapable of performing its functions in relation to food. We are thus driven to the conclusion that it is only by food that the necessary minerals can be conveyed satisfactorily to the system. And so long as rice remains the staple food in the countries under notice, it seems impossible to hope for the extirpation of the disease, as that cereal not only fails to provide the minerals required, but owing to its lack of nitrogen and carbon, is incapable of forming the proteids which would render the individual immune to the attacks of leprosy bacteria.

I do not, of course, say that rice is incapable of taking up the required minerals, but that the paddy fields having remained unmanured for hundreds of years, the soil has been exhausted of those mineral constituents. Proper manuring would, in all probability, render rice a more wholesome food than chemical analysis shows it to be at present.

CONSUMPTION

To turn to another disease, far more widely spread than leprosy, namely, consumption, the recognized medical treatment, which consists largely of iron, phosphates and fats (e.g. cod-liver oil) indicates clearly that the deficiency of certain chemical constituents in the consumptive patient is implicitly recognized. This indicates, from my point of view, that consumption is one of those diseases dependent on food conditions, for, as I point out with reference to leprosy, it is by proper feeding, and not by the administration of drugs, that the different elements can be most satisfactorily replaced.

Dr. Koch has lately laid great stress on his experiments as tending to show that bovine

tuberculosis is not communicable to the human subject. Now, it is just the deficiencies observable in such milk which are also found in the human consumptive, and it seems clear that a child fed on tuberculous milk will thereby be rendered a fruitful soil for the tuberculous microbe; so that it matters little, from the point of view of health, whether the disease is actually communicable direct or not. It is sufficient that feeding upon tuberculous milk or flesh, or milk or flesh derived from animals with a tendency to tuberculosis, will produce in the human that condition which renders him most liable to the disease. Obviously, then, we again come back to the same point. The first thing to be done in the prevention of consumption is to secure mankind from improper, that is, chemically defective food, and, as the necessary corollary, to encourage such agricultural methods as shall provide the food required.

CHAPTER VII

AGRICULTURE

HUMUS

Elements of Agriculture, prepared under authority of the Royal Agricultural Society of England, by W. Fream, LL.D., pp. 15, 16—

"Nevertheless, humus is of great value because the final products of its decomposition, chiefly carbonic acid, ammonia, and water, are capable of administering to the food requirements of growing plants. . . . The quantity of humus usually present in cultivated soils ranges from 2 to 9 per cent., and within these limits the soil will be the richer or more fertile, the more humus it contains. . . . A soil rich in humus is better able to withstand drought."

It is noticeable that in the above passage no reference is made to the quality of the humus; although Storer does speak of the better kinds of humus, yet it may be a chloro-

tic humus, or it may be a humus containing a maximum chlorophyll, or any variation between the two, which variation would be capable of constituting a great chemical difference.

One important point in a normal humus would be that there would be a much higher percentage of iron, nitrogen, and possibly other mineral matter which would be in a thoroughly assimilable form; this would enable the plant to take up the maximum quantity of food in a given period, thus ensuring the largest yield.

The quality of the humus is of the greatest importance again, because humic acid, a product of humus, plays a very important part in the science of agriculture. I very much doubt if its full scope is known or recognized, but there is no question this acid is a solvent of silica, and without going into all the chemical points of the question I think it will appeal to the common sense of most people that a normal humus will be likely to produce a much more potent humic acid than will a chlorotic humus.

If this be so, it is clear that the quality of the vegetable matter which is used to make humus

is of great importance. So important do I think this point that I believe it constitutes the difference between immunity and non-immunity to rust fungus. In other words, if you have a field rich in all the essential mineral constituents, in an assimilable form, and a green crop be grown in this field and ploughed in, and then a cereal crop be grown, this cereal crop will be immune to rust, to say nothing of other parasitical diseases.

While if in another field, very deficient in these assimilable mineral constituents, a green crop was grown of a chlorotic nature, and ploughed in, then the cereal crop grown would not be immune owing to the imperfect chemical functions performed by what I may call a chlorotic humus.

RUST IN WHEAT

From the report of the Rust in Wheat Conference held in Adelaide in 1892, I have come to the conclusion that the debility lies in the straw. My reasons for saying this are the following—

In the first place, the straw of many crops becomes laid—although there is very little

rain in South Australia, only about nine inches per year, and the average yield of wheat is only about eight bushels per acre—so the straw never has an excessive load to carry, consequently there is no ulterior cause why the crop should become laid. Thus, the straw must be weak in itself.

Another point which confirms this theory is that in every case (excepting one experiment) an application of salt decreases the rust in proportion to the increasing quantity used, so that in the case of a heavy dose the rust is nearly banished, and the only value I have ever heard attributed to salt in connexion with a grain crop was that it strengthens the straw by helping to dissolve silica, of which the straw is largely composed, and which has been proved by analysis to be deficient in sugar cane attacked by this disease.

One professor at the Rust Conference said—

" that although he had been in Japan for eight months as adviser to the Government, he did not now remember ever having heard of rust there, although theoretically Japan furnishes conditions almost exactly suited to the de-

velopment of rust. At the same time the straw is so strong and stiff that it never lodges or falls down, although United States Commissioner Capron tells us that nowhere are heavier or more violent gales experienced."

Professor Bloxam, in his *Organic Chemistry*, says—

"that silica is shown by its presence in the shining outer sheath of the stems of the grasses, and creates, particularly in the hard, external coating of the Dutch rush used for polishing."

It is certain the stem of a plant containing the maximum of silica would be more impervious to the fungus than one wanting in silica, and it would also be stronger and not so likely to be laid.

Professor Vogel, a German authority,—

"insists that plants growing in soils rich in silica, but poor in humus, generally take up much less silica than plants grown in soils rich in humus though poor in silica. He holds that

good loam is usually well fitted for supplying silica to plants, the inference being that the humic acids of the organic matter act upon the silicates in the soil slowly to decompose them, and supply the plant roots with some form of soluble silica. Vogel also claims that the presence of much silica in sedges and other inferior herbage of swamps depends upon the abundance of humus in such situations."

No doubt this agrees with Bloxam's statement with regard to the large quantity of silica in the Dutch rush.

Professor Storer, Professor of Agricultural Chemistry, Harvard University, says—

"there is no doubt that the *better* kinds of humus have considerable influence in directly promoting the solution of plant food."

Professor Grandean is very emphatic as to the action of humus on silica.

To condense the whole thing—

1. At the Rust Conference of 1892 it was agreed that the stiff strawed wheats were the best able to resist rust fungus.

2. The Dutch rust is hard, through the

preponderance of silica in it; therefore, if the wheat plant could have all the silica it required it would be hard, especially as the ash of the straw should contain about 70 per cent. of silica.

3. Professors Vogel, Grandean, and Storer all agree that humus is a solvent of silica.

4. Storer lays particular stress on the value of humus to soils that are naturally too dry.

5. In Japan the wheat straw is very strong and rust is practically unknown; it also has a very humid climate and soil. (The above is quoted from the printed report of the Rust in Wheat Conference held in Adelaide in 1892.)

6. Australia, and for that matter, South Africa, are the very reverse of Japan in climate, being very dry, and there is a great deficiency of humus in the soils of both countries.

Therefore I claim that as there is a deficiency in the soil, the wheat plant cannot take up all the silica it requires, and, as far as I am aware, the only practical way of applying humus to the soil is by ploughing in a green crop, which according to Storer is largely influenced by its quality, by so doing the rust fungus will be defeated, that is, if the green

crop which is to make the humus be of a normal character and not chlorotic.

Further, it appears as if the constituents of a normal humus taken up by a plant would be much more fatal to this or any other fungus than the component parts of a chlorotic humus would be.

In fact, it appears as if it is not one special point that is going to render the host immune to a given parasite, but the combination produced by a perfect or normal chemistry that constitutes immunity in the host.

And it is certain that a poor soil wanting in humus is not to be rendered truly fertile by a dressing of a few cwts. of artificial manures per acre, nor is it at all likely to produce a normal vegetable growth.

SUGAR CANE

I would like to point out that the sugar yield of Natal has fallen from five tons per acre down to as low as two tons per acre, and while I understand the yield for 1903 is estimated at four tons, still on the average it requires careful cultivation to obtain from two to three tons per acre. This is a most practical way of

illustrating how the soil has become impoverished.

It has been proved by analysis that a small percentage of iron is extracted from the soil in every crop of cane sugar grown, so it would not take many years to withdraw a fair percentage of this mineral from the soil, as it is an important factor in chlorophyll, and the sugar of the plant being governed by the chlorophyll, as the iron is withdrawn from the soil, so must the yield of sugar decrease.

The cane growers of Natal are paying attention to the restoring of nitrogen to the soil by growing leguminous crops and ploughing them in, but the question of returning iron to the soil is not recognized as necessary, yet its restoration is just as necessary, not only for the production of sugar, but also for the growth of the leguminous crop, as I have previously shown.

One thing is certain—that a normal plant is in a much better position to perform its natural functions than a chlorotic one, therefore it is reasonable to assume that a leguminous crop containing all the mineral constituents will be in a better position to assimilate

nitrogen than a crop wanting in the same.

So that the cane growers of Natal or elsewhere, to obtain the maximum of nitrogen in a given green crop, must manure their land with iron phosphates and potash.

In the chapter on Variation, p. 40, I have quoted an analysis of two sugar-growing soils. If the difference in the iron is so marked in the short span of fifteen years, what must be the condition of millions of acres in Europe and Asia, which have been cultivated for hundreds of years, without ever having had any iron restored to the soil.

It is evident at once that the majority of the soil in those parts of the world that have been cultivated for centuries must have become very deficient, if not entirely wanting, in iron.

This explains why much of the sugar growing of the West Indies has become unprofitable, and why the important crop turnips in England has decreased so in late years. See *The Field* of November 3, 1900.

The absence of iron from rice, to which I have already referred, is perhaps a crucial instance.

OXIDE OF IRON AND AMMONIA

In *Elements of Agriculture*, already referred to, page 19—

"Oxygen combines with iron in several different proportions, and the change in the colour of a subsoil from a bright yellow to a rusty brown may be due to the bright yellow oxide of iron becoming more thoroughly oxidised when the subsoil is exposed to the air at the surface."

On page 20.

In the analysis of four different soils the oxide of iron is . ·92, 5·77, 3·63, 1·52 and the ammonia in the same analyses . ·15, ·19, ·23, ·21 so proving that the percentage of iron in the soil has not in itself the means of fixing the percentage of ammonia.

Since a perfect oxidation of the iron in the soil can only go on through a thorough contact with the air, it follows that a thoroughly aerated soil will have its iron better oxidised and consequently better able to take up ammonia from the air.

Hence a better nitrification will go on in an

aerated soil than in a close heavy soil in which there is a great deficiency of air.

I think this view of the case goes a long way to explain the action of lime on heavy clay soils which in many cases will grow nothing till they have a dressing of three or four tons of lime per acre. Most farmers know that such a dressing of lime will render this heavy land loose and friable like ashes; at least, I have seen this effect in several cases myself, and there can be no question that there would be a much greater circulation of air in such a soil than there would be in a close heavy soil.

As there is no question that oxide of iron does take up ammonia from the air, then there appears to be no reason why iron in the soil should not be as thoroughly oxidised as iron on the surface of the soil, providing always that it can get all the air and consequently oxygen it requires; and if it gets all the oxygen there can be no reason why it should not as readily take up ammonia when in the soil, as oxide of iron does on the surface.

I remember, for instance, experimenting on two acres of heavy dense land, on which nothing would grow, by manuring it with four

tons of lime per acre, with the result that the soil was rendered very loose and friable.

It was then sown to oats, and one of the very finest crops I have ever seen was produced.

One naturally asks what was the change that took place to enable such a crop to be grown. No doubt all the phosphoric acid, potash, and iron that were in the soil were rendered available for plant food, but where did the nitrogen come from ?

It would not be likely to be locked up in such a soil, and if it was one would think the lime would expel it from the soil; at least, lime applied to stable manure drives off the ammonia, and any available nitrogen had no doubt been taken out by such crops as it had previously produced.

So that the aeration and oxidation which no doubt took place, leads one to the natural deduction that the oxidised iron in the soil took up the ammonia, with the resulting nitrification.

The fact remains that nitrogen was an essential constituent of fertile soils for thousands of years before nitrogenous manures were even dreamt of; then where did it come from ?

The answer appears to be that nature must have some all-pervading law in regard to this, as in everything else, and as there is such a fixed law with regard to plant life taking up carbon-dioxide from the air, does it appear likely that there would be no fixed law with regard to such an important constituent as nitrogen ?

BACTERIA OR FUNGI

I have consistently maintained for the last twelve years that parasitic fungi and bacteria can only flourish when the plant (or animal) on which they feed is deficient in chlorophyll or chlorophyll matter, or their products. This view I find borne out by the following passage in the *Encyclopaedia Britannica*, vol. xviii., p. 267—

"It has been seen that the dependence of parasites upon their hosts for the means of subsistence varies considerably in degree, but it is equally manifest that underlying this condition of existence there are certain facts which characterize every case. The most important of these is the absence or the inade-

quate supply of chlorophyll, and the consequent loss or deficiency of the power of assimilation."

In other words, the parasitic fungus will only thrive if the proper food be provided for it. Now fungi are recognized by all authorities as totally wanting in chlorophyll.

The following extract may be taken as illustrative of many others under Schizomycetes, Webster's definition of which is "a group of vegetable micro-organisms which are devoid of chlorophyll as bacteria, micrococci, etc."

In *Encyclopaedia Britannica*, vol. xxi., p. 406, under Schizomycetes, under nutrition, "Having no chlorophyll."

This being so it is an obvious deduction that the plant (or animal) on which they thrive is also so deficient, and this seems to settle the question as to whether the parasite produces the disease, or is a symptom of it. It would of course be folly to maintain that no organic deterioration takes place in the plant (or animal) after the appearance of the fungus.

In fact, as Professor De Barry says in his

Lecture on Bacteria, revised by J. B. Balfour, M.D., F.R.S., on p. 64—

"The vegetative process in organisms which use organic compounds for their food must necessarily effect changes in the substrata from which the food is withdrawn. This is especially the case with organisms whose mode of life is of the kind described, and therefore with all that do not contain chlorophyll, infusoria, and fungi as well as bacteria. Fungi especially in the narrower sense of the word, sprouting fungi, moulds, etc. The interest attaching to bacteria which are devoid of chlorophyll rests chiefly on their effects on their substratum."

I do, however, contend that there is sufficient evidence to show that a more or less chlorotic or anaemic condition of the plant or animal is a necessary preliminary to the appearance of the fungus. In this connexion there is one other interesting point, namely, the effect of iron on fungi.

In a *Text Book of Plant Diseases caused by Cryptogamic Parasites*, Geo. Massee, F.L.S.,

Principal Assistant (Cryptogams), Royal Herbarium, Kew, 1899, says of Fungicides on p. 32—

"From amongst the various solutions and powders that have been experimented with, the following have proved most effective."

The fourth on the list is iron sulphate, and on p. 37 he says—

"This preparation may be used with great advantage in those cases where a disease has previously existed, as it destroys existing spores that may be concealed in crevices of bark, brickwork, or on the ground under the fruit trees. In spraying fruit trees, vines, etc., the trunk and branches should be thoroughly drenched, but it should be done during the winter."

In *Encyclopaedia Britannica*, vol. xxiv. p. 240, on Fungoid Diseases on Vines, it says—

"Peronospora Viticola. This disease has been successfully treated with sulphate of

iron; a solution of this salt prevents the connidia from germinating."

Anthracnose, another fungoid disease, in the same work—

"As a preventative to its attacks a solution of 50 per cent. of iron sulphate has been very useful."

We here find iron inimical to the growth of certain specified fungi, and no doubt further experiment would indefinitely enlarge the list. Now, I have shown conclusively that iron is a main ingredient of chlorophyll, hence we have further evidence, if it were needed, that a plant containing a normal chlorophyll will afford a most unhealthy soil for the growth of fungi, and if unhealthy to the growth of fungi in plant life, there can be no reason why the presence of iron should not retard or absolutely prevent the growth of fungi, otherwise bacteria, in animal life when taken in by the food.

NITROGEN AND FATS

Scientific American Supplement, February 9,

1901, under "Corn Growing." Results of twelve years' work at the experiment stations.

"The improvement of the food value of corn by changing its chemical composition is being undertaken at the Illinois station.

"The method is to select corn of higher (or lower) protein contents for seed.

"At harvest time kernels from years analysing highest (or lowest) in protein are selected as seed for the succeeding crop. This process is repeated each year, the idea being to fix by inheritance the character sought in the highest degree.

"The fat content is being changed in the same way.

"Thus far differences varying from 0·5 per cent. to 1·25 per cent. of protein, and from 0·67 per cent. to 1·45 per cent. of fat have been obtained.

"These variations are believed to show that it is possible to increase or decrease any of the principal constituents of corn by proper selection, and thus materially alter its composition.

The *Encyclopaedia Britannica*, vol. xix., p. 54.

"The nitrogenous plastic products are proteids. With regards to the fats, it is commonly assumed that they are formed directly from the carbohydrates."

From the foregoing it is clear that the Illinois agricultural experts are trying to improve the feeding value of Indian corn by selection.

It may be possible to do this to a small extent, but the fundamental basis of the subject is chemistry, as I will try to show.

In the Illinois report we have distinct evidence that the proteids and fats vary considerably in maize, and are deficient in some samples just as they are wanting in some samples of rice.

The proteids being in the main carbon compounds, and as the carbon and hydrogen of the plant are governed by the chlorophyll, and the main factors in chlorohpyll being iron and nitrogen, which vary considerably in the plant, then so must the chlorophyll vary, and consequently the carbon and hydrogen and nitrogen of the proteids, so that the proteids must vary as the chemistry of the plant and consequently of the soil.

And as the percentage of iron varies from, say 16 per cent. to ·000, it is easy to understand how the carbon, hydrogen and nitrogen may vary, which will account for the variation in the percentage of proteids as found in corn at the Illinois station.

And to try and fix the proteids by inheritance is in the main waste of time, for if corn rich in proteids be sown in a poor soil for a few years consecutively, we shall see a rapid disappearance of the same. Otherwise, how is it that an inferior soil, after being sown to wheat for a few years, will return a yield less in quantity than and inferior in quality to the seed sown.

As vegetable fats are thought to be produced direct from the carbohydrates, it is easy to understand how they are governed by the same law.

As the fats are deficient and vary in rice and corn, and knowing that other foods grow under the same laws, it is reasonable to assume that the nitrogen and fats of other foods vary in the same way. Rice as a food is recognized as being poor owing to its deficiency in nitrogen and fats, and considered conducive to

certain diseases ; then other foods deficient in nitrogen and fats will be poor foods conducive to many diseases.

And that such poor foods do exist the world over is proved by the fact that doctors are constantly giving patients iron, cod-liver oil, quinine, etc. In plain English, they are trying to supply to the blood iron and materials to make proteids and fats by means of various drugs, that would be supplied by normal foods much more effectively than by any drugs.

In fact, no drugs can ever take the place of normal foods, as nature requires the proteids to be supplied daily by the food, and if the food is deficient in these important constituents, then the animal economy must also be deficient.

FRUIT TREES AND CHLOROSIS

It is admitted that chlorosis is one of the most prevalent diseases of the vegetable world, and I have found it specially rife in the orange tree in South Africa.

Unless the trees have been more or less artificially manured I do not think it possible to

go into a South African orange grove which is not suffering from chlorosis.

It is evident even to an ordinary observer, for you will see the young leaves quite yellow, and sometimes the top half of a large tree yellow, and it is quite common for farmers to tell you they are losing several trees per year, but they cannot understand they are dying from poverty.

There is another important feature about these chlorotic trees.

They will be found as a rule to be covered with muscle scale, and if they are not it will be because they have been fumigated. You will also find the fruit of chlorotic trees very deficient in sugar—in fact, the juice of an orange of such a tree is neither sweet nor sticky as it should be.

As the sugar is distinctly a carbon compound, and the carbon is controlled by the chlorophyll, it follows as the sugar is defective so is the chlorophyll.

Therefore manure to cure the chlorosis, and you will produce a fine sugary orange; that is, providing there are other necessary constituents present, like potash, which has the

power to turn starch into sugar, and at the same time banish the creeping fungus, otherwise scale, from the trees.

These results I have seen obtained by manuring orange trees in South Africa.

As evidence on this subject Mr. H. Tiffin says that on the "Meeting of the Waters" Farm, Queenstown District, South Africa, in the year 1896—

"he treated the only two orange trees on the farm, which had very yellow leaves and were dying, with a quantity of very rusty iron at the roots, and says three months afterwards you could see a distinct improvement in the trees, and the next year the trees were much improved."

And on the "Mopassa" Farm, in the same district, where nearly all the orange trees were dead from the same cause—

"Round one orange tree was placed a quantity of rust with perfectly satisfactory results."

Mr. Tiffin also says "that while the orange trees recovered, and were much improved by the application of iron to the roots, still there

was room for improvement, only he did not know what to give them."

Mr. John Kemp, of Spanover Cathcart, South Africa, says—

"He has thirty orange trees thirteen years old. When he planted them he placed a large cask at the top end of the row. This cask he used nearly to fill with cow manure, and fill up with water, letting it stand for two days before irrigating the orange trees, when he used to let all the irrigation water flow through the cask, the cask having a larger intake than outlet, so turning the irrigation water into a mild liquid manure, with the result that the trees were always healthy, much to the astonishment of neighbours, who had trees infected with scale."

To prove the trees were thriving, one year two oranges were picked which measured 18″ and 16″ in circumference respectively.

For the last three years he has refrained from giving the trees this liquid manure, with the result that they have become infested with scale, and it was only two or three weeks before I visited the farm that the trees had been

fumigated with cyanide of potassium. Mr. Kemp is so satisfied with my views that he intends remanuring his trees.

I would like to mention here that there is no tree so easily killed from over-manuring as the orange tree, and farmers should be very careful on this point.

Another fruit that suffers greatly from chlorosis in South Africa is the pineapple, so much so that in many cases it is not worth eating.

This fruit is also largely damaged by parasites, including the locust. While writing on chlorosis of plants I cannot conclude without mentioning the yellows, a fungoid disease that destroys thousands of peach trees in America every year.

As it is admitted a weak solution of sulphate of iron turns the leaves green, and that nitrates have the same effect, and as iron and nitrogen are distinct poisons to the fungi, it appears reasonable to think any chemical compound that would keep the leaves green, and that at the same time would be a natural poison to the fungus, would prevent the trees from dying of this disease.

It would be at least an interesting experiment to see which would win.

I wish to make it clear at this point that while the want of iron in the chlorophyll or haemoglobin is always associated with chlorosis or anaemia it should also be remembered that a want of nitrogen or, what follows, of carbon brings about much the same condition of things.

In fact, the want of one more or less involves the want of the others; therefore chlorosis or anaemia cannot be accurately described as a deficiency of iron in the plant or animal, as the absolute want of potash in the soil will prevent the plant from assimilating either iron or phosphoric acid in the way it should, and the same deficiency will prevent the movement of starch in the plant.

This will cause the plant to be defective in nitrogen, consequently chlorotic, and wanting in chlorophyll and all the carbon compounds.

I have written on this point at some length in order to make it clear that a deficiency of one element upsets the whole chemistry of the plant, and must act more or less in the same

way on the animals eating the said fruits or plants.

As evidence that a chemical change has taken place in some South African pastures, a farmer with whom I was in conversation told me that when he first settled on his farm the natural flowers of the country were violet, blue, red, yellow, etc., but that at the time of speaking (1898) all the flowers had become white, and he mentioned this as evidence that some change had taken place in the soil.

He had been living on the farm for about thirty years. No doubt the colouring pigment of the flowers had become exhausted, and without asserting that iron was the pigment that was wanting in these flowers, it is quite safe to say iron is the most powerful colouring pigment of the higher plants and animals.

To show that this changing of the colour in flowers was not of a local nature, in conversation with a lady in the Queenstown district who took a great interest in flowers, she mentioned she had noticed the roses were much lighter in colour than they had been years before.

The farmer mentioned lived near Bedford,

so that the two localities were hundreds of miles apart.

In order to show that the effect of the change of soil upon the vegetation does not stop there, it is important to note that the district in which the above mentioned farmer lived is one in which heartwater is rife. He is one of the very few who have noticed that a large percentage, if not all, the blood of an animal suffering from heartwater would not coagulate, but sink into the ground like water.

WEEDS, INSECTS AND MANURES

For several years I have maintained that many weeds owe their existence to an impoverished soil. I have noticed, for example, that the presence of sorrel was always coincident with a deficiency of nitrogen, and have found that after manuring with a nitrogenous manure, the sorrel dwindled and died away.

I have also noticed that when land was limed on which Cape weed was growing, white clover and other herbage grew to the extermination of this weed. Again, there are the dodders, parasitic plants containing no chlorophyll (see *Encyclopædia Britannica*, vol. xviii.,

p. 264), which practical farmers know can be killed by spraying with a solution of sulphate of iron. The chemical action of this solution on a plant would be towards producing chlorophyll, and as the dodders contain no chlorophyll, the chemical change produced would be inimical to their growth ; in other words, the iron acts as a poison to them. This chlorosis being a common disease among the higher plants, the presence of the parasitic dodder may be taken as an indication of the chlorotic state, for the conditions which will cure chlorosis will kill the dodder. In other words, when the soil is of such a nature as to produce chlorophyll in the plant, the dodders, and, as I believe, many other weeds will not thrive in it. It has been shown by practical experiment, sometimes made accidentally at great cost, as in the case of destroying a whole orange grove, that if you give plants too much phosphates, potash and nitrogen, you will kill them, and knowing that many soils are very deficient, if not entirely wanting, in iron, in which soils I feel sure it will be found such weeds as the dodders, charlock, Canadian thistle, and an innumerable number of other

weeds thrive, it is easy to understand how a dressing of iron to the soil that would be very beneficial to our common farm crops like the cereals, clovers, turnips, etc., would be very injurious to many of these weeds.

This is certainly the case with two forms of plant life, the fungi and cuscuta.

Considering these plants as parasites of higher forms of plant life, the evidence, though not conclusive, goes to show that they live upon the higher forms only when these latter are deficient in chlorophyll matters, by which I mean not only iron and nitrogen, but the proteids generally. We know of fungi ranging from the smallest bacteria up to mushrooms, the marked feature of their existence being an entire absence of chlorophyll. We also have several cuscuta which, I take it, are a higher form of plant life than the fungi, containing no chlorophyll. We have creeping fungi, as well as certain low forms of animal life, such as slugs, which do considerable damage. Slugs, indeed, living as they do like the fungi mainly upon decaying vegetable matter, are not unlike creeping fungi, and I believe it can be shown that they are chemically of a similar

composition. Turning to insect pests, we may take the case of the cockchafer.

In *Insect World*, by Louis Figuier, revised by P. Martin Duncan, F.R.S., p. 465, on the cockchafer—

" Or you may sow in the field rape seed very thickly, which you must then bury by a very deep ploughing, when it is as high as your hand. Colewort, it is said, kills the larvae, while it at the same time manures the land."

Miss Ormerod, in one of her works, writing on the cockchafer, says—

" Where the larvae of the cockchafer were placed in a box of soil and covered with half an inch of soil, and then manured with a light dressing of nitrate of soda, the larvae were killed, while a similar lot treated in the same way with a heavy dressing of salt were not injured in the least."

In this instance we find that the presence of nitrogen, either in the form of a rape crop or as nitrate of soda, is fatal to this insect. In

other words, by manuring with nitrate, there is a tendency to change the chemistry of the insect in a way that is fatal to it by producing more or less chlorophyll matter.

Yet another insect to which the chemical constituents that go to the making of chlorophyll appear to be noxious is the locust.

That this view is not unreasonable is evident from the remarks made on the subject in a Micrographical Dictionary by J. W. Griffith, M.D., and A. Henfrey, F.R.S., F.L.S., Professor of Botany, in King's College, London, under "Blood"—

"The blood of the invertebrata has not been so thoroughly examined. In many of them there are two circulating liquids—one coloured and sometimes containing hæmatine, but no corpuscles; the other colourless nucleated corpuscles, much resembling the colourless corpuscles of the vertebrata. The colouring matter of the aphides partakes of the nature of chlorophyll."

The locust is an invertebrate with a more or less colourless circulating fluid. It is a

well established fact that locusts exercise great discrimination with regard to the foods they eat.

It is a fact that locusts eat some plants with more avidity than others ; it also appears there are plants the leaves of which they will not eat. For instance, I am told they will not eat the leaves of chicory plants or sweet potatoes, sometimes peas and other plants, and always have a greater preference for some plants than others.

On one farm near East London it was noticed on one occasion where barley, sweet potatoes and pineapple plants were growing close together (the potato vines were amongst the pine plants) that the locusts ate the leaves of the pine plants but did not touch the barley or potato vines. On another occasion, where the locusts had devoured all the crops growing on many square miles of country, one farmer in the devastated district had a few rows of peas untouched, and I have been told of many other instances where the locusts had devoured one form of plant life, but not another which was growing close or intermixed with the one devoured.

Mr. A. Miles, of Thornley, Cathcart, South Africa, says—

"He noticed in riding through a field that had been planted with mealies, or Indian corn, and was invaded by locusts when the plants were a few inches high, that while most of the field was eaten down there were two strips practically untouched. Afterwards a rain came and the roots of the devoured plants made a fresh growth, and again when the stalks of the uneaten plants had the cobs formed and those that had been eaten gave every indication of still giving a crop, the locusts appeared for the second time, and destroyed all the plants on the ground previously attacked, while the mealie plants they first refused to eat still remained immune to this pest."

What the reason was Mr. Miles does not know, but these are the facts.

As further evidence, Mr. A. Francis, of Fairford, Cathcart, says—

"There is no question that some vegetation is much more tasteful to, or liable to be eaten,

by locusts than other vegetation, and it was noticeable on his farm that a piece of rich flat formed by the washings from the surrounding ironstone hills which form one side of the Kromme River valley produced mealies and potatoes that were not at all to the liking of these insects, as they left these particular crops after doing very little damage, while similar crops growing on soil that could not be benefited by the washings from these ironstone hills were entirely destroyed by the same lot of locusts."

With evidence of this nature before us it must appeal to any one's common sense that the reason why locusts eat some forms of plant life in preference to other forms should be investigated as being of more importance than the question of manure and weeds, although I think the two questions are directly connected.

In connexion with the locusts, chemical deduction gives us some points that will stand investigation.

First, plants that appear most distasteful to locusts are those containing a considerable

percentage of sugar. Readers familiar with locusts will say they are very fond of sugar, and they may be, but sugar is a chemical compound governed by the iron and nitrogen of the plant. We have the testimony of Mr. Francis that locusts did not injure crops growing on soils rich in iron. Then we have the fact that locusts would not eat pea plants when devouring everything on the surrounding country.

Peas are said to extract nitrogen from the air, and they may be more potent for extracting inert iron out of the soil ; in any case, the fact remains that the plant with a greater tendency to normality than its neighbour remained immune to this insect.

So also sweet potato vines which have the power of producing more sugar than the average plant, and consequently likely to be richer in chlorophyll products, have a tendency to remain immune to this pest.

It seems clear, then, that as the locust attacks by preference those plants which are less likely to be rich in chlorophyll, the best protection against their inroads lies in the provision of a normal soil capable of providing the plant

with the constituents necessary for the production of a normal chlorophyll.

If such crops are immune, then two points will have been proved: first, that a crop grown on a normal soil is immune to locusts; and secondly, that these insects are an extension of the fungi.

If crops so grown prove to be immune to locusts, we are already far along the road to prove that the ravages of insects and fungi are due to the same cause and can be counteracted by identical or at least similar remedies.

In the aphides we have another class of insect, where at least a trace of chlorophyll is recognized. The phylloxera of vines and the aphis of apple trees are two well-known insects of this class, and any observer must have noticed that apple trees attacked by this disease always have a very dark bark, and not a green bark like one containing chlorophyll.

An interesting point in connexion with this fact is that lime plays an important part in this disease, for it is proved by analysis that trees attacked by this disease are very deficient

in lime, while those immune to it contain a higher percentage of this mineral.

One can understand the lime disintegrating the soil so that the roots can avail themselves of every particle of iron, irrespective of a better oxidation of the said iron, which I believe leads to an increased nitrification, as explained under Nitrogen ; but beyond that it looks as if the presence of lime had something to do with this nitrification, which, as far as I know at present, is neither recognized nor understood. But the fact remains that liming the soil round trees suffering from aphis produces a healthier growth, and under favourable circumstances, drives off the aphis, which I have not the least doubt would be destroyed if the soil were also manured with iron.

Professor E. W. Hilgard, Director of the College of Agriculture, California, says—

"The attack of phylloxera on the vines produces a diminution of potash and albumen normally contained in the juice. The indication that potash with nitrogenous manures would mitigate the effect on the vines produced by phylloxera has been verified by experience.

The use of these manures alone has so far improved the condition of the vines as to neutralize the injuries done by the insect and restore them to their usual productiveness. In all cases where the vines were not too far gone, the condition has been materially improved by the application."

Mr. Hilgard says—"Phylloxera on the vines produces a diminution of potash."

Personally, I should like to know how Mr. Hilgard arrives at this point; it being a well-known fact that from Spain alone very large quantities of tartrate of potash are exported. Tartar is an acidulous concrete salt deposited by wine, forming a crust on the bottom and sides of casks in which that liquid is kept.

It is estimated that one ton of grapes will produce from one to two pounds of crude tartar. No doubt the weight of grapes required to produce this tartar varies with the quality of the grape, but the fact remains that every pound of grapes carried away, whether for the manufacture of wine or brandy or for eating, must take so much tartrate from the soil.

It follows that in time the soil must become very impoverished in this mineral, to say nothing of the other mineral constituents.

This view of the case appears to me to be much more practical, and more within the lines of common sense, than to suppose that the phylloxera causes a diminution of potash.

And as Professor Hilgard says—

"Potash with nitrogenous manure would mitigate the effect on the vine produced by phylloxera, has been verified by experience."

If the vines had been manured with plenty of iron, some potash and phosphates, I have not the least doubt no such thing as phylloxera would ever be heard of; for the reason that the vines would be so healthy and full of chlorophyll matter as to give these aphides not a trace, but a large dose of this chemical compound which, instead of being a food, would be a poison to this insect.

I have now pointed out that there are forms of insect life that are to all intents and purposes simply an extension of the fungi. Nor is the list of these insect pests exhausted, for

among many others I may name the hop fly, turnip fly, oak moth and codlin moth as worthy of special study on these lines.

What I wish to put forward as my contention is that side by side with the normal vegetation having a proper chlorophyll, there exists a class of vegetable and animal life which depends upon the chlorotic specimens for its food and for its very existence.

The leading feature of the first form of life is that the plants contain a chemical compound known as chlorophyll and the animals a chemical compound known as haemoglobin, which is simply a change of colour produced in the animals when they eat the green colouring matter, or the substance which represents it in foods, such as roots, which are not exposed to the sun's rays.

The second form of life is composed of various plants and insects, the leading feature of this class being that none of the plants contain any chlorophyll and the insects are devoid of chlorophyll or its red modification haemoglobin. Between these two extremes we have both plants and insects, like charlock and the aphides, as a sort of connecting link.

I contend that it is a natural law that these two forms of life are always more or less at war, or in other words, nature is always destroying that which is imperfect. And just as there are insects like the aphides which can destroy plant life that has more vitality than, for instance, the orange tree when attacked by scale, so also there are bacterial or fungoid diseases of animal life which can attack this life when the vitality is only lowered below the normal, while others are only deadly when the vitality is at its lowest ebb.

The higher form will always be able to resist while its chlorophyll or haemoglobin is within a given number of points of normal, the virulence of the attack varying as the number of points decrease from the normal and the range of normality varying according to the attacking force.

From this I draw one conclusion: that if we keep the higher forms of life at something approaching normality, they will be immune or impregnable to the attacking force.